

**ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE**

I

RULES FOR CONSTRUCTION OF POWER BOILERS

**2001 Edition
July 1, 2001**

**ASME BOILER AND
PRESSURE VESSEL
COMMITTEE
SUBCOMMITTEE ON
POWER BOILERS**

**THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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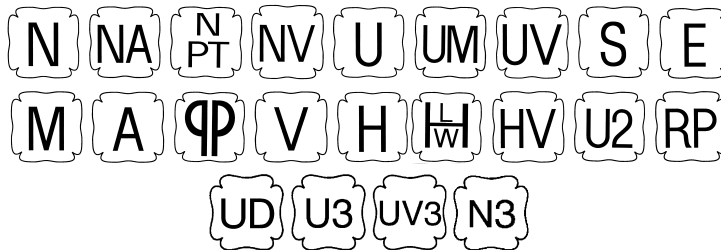
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BOILER AND PRESSURE VESSEL CODE

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ADDENDA

Colored-sheet Addenda, which include additions and revisions to individual Sections of the Code, are published annually and will be sent automatically to purchasers of the applicable Sections up to the publication of the 2004 Code. The 2001 Code is available only in the loose-leaf format; accordingly, the Addenda will be issued in the loose-leaf, replacement-page format.

INTERPRETATIONS

ASME issues written replies to inquiries concerning interpretation of technical aspects of the Code. The Interpretations for each individual Section will be published separately and will be included as part of the update service to that Section. They will be issued semiannually (July and December) up to the publication of the 2004 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA.

CODE CASES

The Boiler and Pressure Vessel Committee meets regularly to consider proposed additions and revisions to the Code and to formulate Cases to clarify the intent of existing requirements or provide, when the need is urgent, rules for materials or constructions not covered by existing Code rules. Those Cases which have been adopted will appear in the appropriate 2001 Code Cases book: (1) Boilers and Pressure Vessels and (2) Nuclear Components. Supplements will be sent automatically to the purchasers of the Code Cases books up to the publication of the 2004 Code.



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FOREWORD

The American Society of Mechanical Engineers set up a committee in 1911 for the purpose of formulating standard rules for the construction of steam boilers and other pressure vessels. This committee is now called the Boiler and Pressure Vessel Committee.

The Committee's function is to establish rules of safety governing the design, fabrication, and inspection during construction of boilers and pressure vessels, and to interpret these rules when questions arise regarding their intent. In formulating the rules, the Committee considers the needs of users, manufacturers, and inspectors of pressure vessels. The objective of the rules is to afford reasonably certain protection of life and property and to provide a margin for deterioration in service so as to give a reasonably long, safe period of usefulness. Advancements in design and material and the evidence of experience have been recognized.

This Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction¹ activities. The Code does not address all aspects of these activities and those aspects that are not specifically addressed should not be considered prohibited. The Code is not a handbook and cannot replace education, experience, and the use of engineering judgment. The phrase *engineering judgment* refers to technical judgments made by knowledgeable designers experienced in the application of the Code. Engineering judgments must be consistent with Code philosophy and such judgments must never be used to overrule mandatory requirements or specific prohibitions of the Code.

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code neither requires nor prohibits the use of computers for the design or analysis of components constructed to the requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they

are responsible for all technical assumptions inherent in the programs they use and they are responsible for the application of these programs to their design.

The Code does not fully address tolerances. When dimensions, sizes, or other parameters are not specified with tolerances, the values of these parameters are considered nominal and allowable tolerances or local variances may be considered acceptable when based on engineering judgment and standard practices as determined by the designer.

The Boiler and Pressure Vessel Committee deals with the care and inspection of boilers and pressure vessels in service only to the extent of providing suggested rules of good practice as an aid to owners and their inspectors.

The rules established by the Committee are not to be interpreted as approving, recommending, or endorsing any proprietary or specific design or as limiting in any way the manufacturer's freedom to choose any method of design or any form of construction that conforms to the Code rules.

The Boiler and Pressure Vessel Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code Cases, and requests for interpretations. Only the Boiler and Pressure Vessel Committee has the authority to provide official interpretations of this Code. Requests for revisions, new rules, Code Cases, or interpretations shall be addressed to the Secretary in writing and shall give full particulars in order to receive consideration and action (see Mandatory Appendix covering preparation of technical inquiries). Proposed revisions to the Code resulting from inquiries will be presented to the Main Committee for appropriate action. The action of the Main Committee becomes effective only after confirmation by letter ballot of the Committee and approval by ASME.

Proposed revisions to the Code approved by the Committee are submitted to the American National Standards Institute and published in *Mechanical Engineering* to invite comments from all interested persons. After the allotted time for public review and final approval by ASME, revisions are published annually in Addenda to the Code.

¹Construction, as used in this Foreword, is an all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification, and pressure relief.

Code Cases may be used in the construction of components to be stamped with the ASME Code symbol beginning with the date of their approval by ASME.

After Code revisions are approved by ASME, they may be used beginning with the date of issuance shown on the Addenda. Revisions, except for revisions to material specifications in Section II, Parts A and B, become mandatory 6 months after such date of issuance, except for boilers or pressure vessels contracted for prior to the end of the 6 month period. Revisions to material specifications are originated by the American Society for Testing and Materials (ASTM), and other recognized national or international organizations and are usually adopted by ASME. However, those revisions may or may not have any effect on the suitability of material, produced to earlier editions of specifications, for use in ASME construction. ASME material specifications approved for use in each construction Code are listed in the Appendices of Section II, Parts A and B. These Appendices list, for each specification, the latest edition adopted by ASME, and earlier and later editions considered by ASME to be identical for ASME construction.

Manufacturers and users of components are cautioned against making use of revisions and Cases that are less restrictive than former requirements without having assurance that they have been accepted by the proper authorities in the jurisdiction where the component is to be installed.

Each state and municipality in the United States and each province in Canada that adopts or accepts one or more Sections of the Boiler and Pressure Vessel Code is invited to appoint a representative to act on the Conference Committee to the Boiler and Pressure Vessel Committee. Since the members of the Conference Committee are in active contact with the administration and enforcement of the rules, the requirements for inspection in this Code correspond with those in effect in their respective jurisdictions. The required qualifications for an Authorized Inspector under these rules may be obtained from the administrative authority of any state, municipality, or province which has adopted these rules.

The Boiler and Pressure Vessel Committee in the formulation of its rules and in the establishment of maximum design and operating pressures considers materials, construction, methods of fabrication, inspection, and safety devices. Permission may be granted to regulatory bodies and organizations publishing safety standards to use a complete Section of the Code by reference. If usage of a Section, such as Section IX, involves exceptions, omissions, or changes in provisions, the intent of the Code might not be attained.

Where a state or other regulatory body, in the printing of any Section of the Boiler and Pressure Vessel Code, makes additions or omissions, it is recommended that such changes be clearly indicated.

The National Board of Boiler and Pressure Vessel Inspectors is composed of chief inspectors of states and municipalities in the United States and of provinces in Canada that have adopted the Boiler and Pressure Vessel Code. This Board, since its organization in 1919, has functioned to uniformly administer and enforce the rules of the Boiler and Pressure Vessel Code. The cooperation of that organization with the Boiler and Pressure Vessel Committee has been extremely helpful.

The Code Committee does not rule on whether a component shall or shall not be constructed to the provisions of the Code. The Scope of each Section has been established to identify the components and parameters considered by the Committee in formulating the Code rules. Laws or regulations issued by municipality, state, provincial, federal, or other enforcement or regulatory bodies having jurisdiction at the location of an installation establish the mandatory applicability of the Code rules, in whole or in part, within their jurisdiction. Those laws or regulations may require the use of this Code for vessels or components not considered to be within its Scope or may establish additions or deletions in that Scope. Accordingly, inquiries regarding such laws or regulations are to be directed to the issuing enforcement or regulatory body.

Questions or issues regarding compliance of a specific component with the Code rules are to be directed to the ASME Certificate Holder (Manufacturer). Inquiries concerning the interpretation of the Code are to be directed to the ASME Boiler and Pressure Vessel Committee. ASME is to be notified should questions arise concerning improper use of an ASME Code symbol.

The specifications for materials given in Section II are identical with or similar to those of the Specifications published by ASTM, AWS, and other recognized national or international organizations. When reference is made in an ASME material specification to a non-ASME specification for which a companion ASME specification exists, the reference shall be interpreted as applying to the ASME material specification. Not all materials included in the material specifications in Section II have been adopted for Code use. Usage is limited to those materials and grades adopted by at least one of the other Sections of the Code for application under rules of that Section. All materials allowed by these various Sections and used for construction within the scope of their rules shall be furnished in accordance with material specifications contained in

Section II or referenced in Appendices A of Section II, Parts A and B except where otherwise provided in Code Cases or in the applicable Section of the Code. Materials covered by these specifications are acceptable for use in items covered by the Code Sections only to the degree indicated in the applicable Section. Materials for Code use should preferably be ordered, produced, and documented on this basis; Appendix A to Section II, Part A and Appendix A to Section II, Part B list editions of ASME and year dates of specifications that meet ASME requirements and that may be used in Code construction. Material produced to an acceptable specification with requirements different from the requirements of the corresponding specifications listed in Appendix A of Part A or Part B may also be used

in accordance with the above, provided the material manufacturer or vessel manufacturer certifies with evidence acceptable to the Authorized Inspector that the corresponding requirements of specifications listed in Appendix A of Part A or Part B have been met. Material produced to an acceptable material specification is not limited as to country of origin.

When required by context in this Section, the singular shall be interpreted as the plural, and vice-versa; and the feminine, masculine, or neuter gender shall be treated as such other gender as appropriate.

Publication of the SI (Metric) Edition of the ASME Boiler and Pressure Vessel Code was discontinued with the 1986 Edition. Effective October 1, 1986, the SI Edition was withdrawn as an ASME Boiler and Pressure Vessel Code document.

STATEMENT OF POLICY ON THE USE OF CODE SYMBOLS AND CODE AUTHORIZATION IN ADVERTISING

ASME has established procedures to authorize qualified organizations to perform various activities in accordance with the requirements of the ASME Boiler and Pressure Vessel Code. It is the aim of the Society to provide recognition of organizations so authorized. An organization holding authorization to perform various activities in accordance with the requirements of the Code may state this capability in its advertising literature.

Organizations that are authorized to use Code Symbols for marking items or constructions that have been constructed and inspected in compliance with the ASME Boiler and Pressure Vessel Code are issued Certificates of Authorization. It is the aim of the Society to maintain the standing of the Code Symbols for the benefit of the users, the enforcement jurisdictions, and the holders of the symbols who comply with all requirements.

Based on these objectives, the following policy has been established on the usage in advertising of facsimiles of the symbols, Certificates of Authorization, and reference to Code construction. The American Society of Mechanical Engineers does not “approve,” “certify,”

“rate,” or “endorse” any item, construction, or activity and there shall be no statements or implications that might so indicate. An organization holding a Code Symbol and/or a Certificate of Authorization may state in advertising literature that items, constructions, or activities “are built (produced or performed) or activities conducted in accordance with the requirements of the ASME Boiler and Pressure Vessel Code,” or “meet the requirements of the ASME Boiler and Pressure Vessel Code.”

The ASME Symbol shall be used only for stamping and nameplates as specifically provided in the Code. However, facsimiles may be used for the purpose of fostering the use of such construction. Such usage may be by an association or a society, or by a holder of a Code Symbol who may also use the facsimile in advertising to show that clearly specified items will carry the symbol. General usage is permitted only when all of a manufacturer’s items are constructed under the rules.

The ASME logo, which is the cloverleaf with the letters ASME within, shall not be used by any organization other than ASME.

STATEMENT OF POLICY ON THE USE OF ASME MARKING TO IDENTIFY MANUFACTURED ITEMS

The ASME Boiler and Pressure Vessel Code provides rules for the construction of boilers, pressure vessels, and nuclear components. This includes requirements for materials, design, fabrication, examination, inspection, and stamping. Items constructed in accordance with all of the applicable rules of the Code are identified with the official Code Symbol Stamp described in the governing Section of the Code.

Markings such as “ASME,” “ASME Standard,” or any other marking including “ASME” or the various Code Symbols shall not be used on any item that is

not constructed in accordance with all of the applicable requirements of the Code.

Items shall not be described on ASME Data Report Forms nor on similar forms referring to ASME that tend to imply that all Code requirements have been met when, in fact, they have not been. Data Report Forms covering items not fully complying with ASME requirements should not refer to ASME or they should clearly identify all exceptions to the ASME requirements.

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PREAMBLE

This Code covers rules for construction of power boilers,¹ electric boilers,² miniature boilers,³ and high-temperature water boilers⁴ to be used in stationary service and includes those power boilers used in locomotive, portable, and traction service. Reference to a paragraph includes all the subparagraphs and subdivisions under that paragraph.

The Code does not contain rules to cover all details of design and construction. Where complete details are not given, it is intended that the manufacturer, subject to the acceptance of the Authorized Inspector, shall provide details of design and construction which will be as safe as otherwise provided by the rules in the Code.

The scope of jurisdiction of Section I applies to the boiler proper and to the boiler external piping.

Superheaters, economizers, and other pressure parts connected directly to the boiler without intervening valves shall be considered as parts of the boiler proper, and their construction shall conform to Section I rules.

Boiler external piping shall be considered as that piping which begins where the boiler proper or separately fired superheater terminates at:

- (a) the first circumferential joint for welding end connections; or
- (b) the face of the first flange in bolted flanged connections; or
- (c) the first threaded joint in that type of connection; and which extends up to and including the valve or valves required by this Code.

ASME Code Certification (including Data Forms and Code Symbol Stamping), and/or inspection by the Authorized Inspector, when required by this Code, is required for the boiler proper and the boiler external piping.

¹Power boiler — a boiler in which steam or other vapor is generated at a pressure of more than 15 psi for use external to itself.

²Electric boiler — a power boiler or a high-temperature water boiler in which the source of heat is electricity.

³Miniature boiler — a power boiler or a high-temperature water boiler in which the limits specified in PMB-2 are not exceeded.

⁴High-temperature water boiler — a water boiler intended for operation at pressures in excess of 160 psi and/or temperatures in excess of 250°F.

Construction rules for materials, design, fabrication, installation, and testing of the boiler external piping are contained in ASME B31.1, Power Piping. Piping beyond the valve or valves required by Section I is not within the scope of Section I, and it is not the intent that the Code Symbol Stamp be applied to such piping or any other piping.

The material for forced-circulation boilers, boilers with no fixed steam and water line, and high-temperature water boilers shall conform to the requirements of the Code. All other requirements shall also be met except where they relate to special features of construction made necessary in boilers of these types, and to accessories that are manifestly not needed or used in connection with such boilers, such as water gages and water columns.

Reheaters receiving steam which has passed through part of a turbine or other prime mover and separately fired steam superheaters which are not integral with the boiler are considered fired pressure vessels and their construction shall comply with Code requirements for superheaters, including safety devices. Piping between the reheater connections and the turbine or other prime mover is not within the scope of the Code.

A pressure vessel in which steam is generated by the application of heat resulting from the combustion of fuel (solid, liquid, or gaseous) shall be classed as a fired steam boiler.

Unfired pressure vessels in which steam is generated shall be classed as unfired steam boilers with the following exceptions:

- (a) vessels known as evaporators or heat exchangers;
- (b) vessels in which steam is generated by the use of heat resulting from operation of a processing system containing a number of pressure vessels such as used in the manufacture of chemical and petroleum products.

Unfired steam boilers shall be constructed under the provisions of Section I or Section VIII.

Expansion tanks required in connection with high-temperature water boilers shall be constructed to the requirements of Section I or Section VIII.

A pressure vessel in which an organic fluid is vaporized by the application of heat resulting from the combustion of fuel (solid, liquid, or gaseous) shall be constructed under the provisions of Section I. Vessels in which vapor is generated incidental to the operation of a processing system, containing a number of pressure vessels such as used in chemical and petroleum manufacture, are not covered by the rules of Section I.

The 2001 Edition of the Code contains both U.S. Customary and SI units. In all cases, the U.S. Customary units are the standard and SI units are provided for the convenience of the user.

SUMMARY OF CHANGES

The 2001 Edition of this Code contains revisions in addition to the 1998 Edition with 1999 and 2000 Addenda. The revisions are identified with the designation **01** in the margin and, as described in the Foreword, become mandatory six months after the publication date of the 2001 Edition. To invoke these revisions before their mandatory date, use the designation "2001 Edition" in documentation required by this Code. If you choose not to invoke these revisions before their mandatory date, use the designation "1998 Edition through the 2000 Addenda" in documentation required by this Code.

Changes given below are identified on the pages by a margin note, **01**, placed next to the affected area.

<i>Page</i>	<i>Location</i>	<i>Change</i>
6	PG-6	SA/EN-10028-2 added
7, 8	PG-9.1	SA-226 deleted
	PG-9.2	SB-166, SB-167, SB-168, SB-516, and SB-517 added
	PG-9.5	Added
13	PG-19	Footnote 8 added
	Footnote 8	Added
16	PG-25.2.1.1	Revised
17	PG-25.2.2.2	Revised
19	PG-27.3, Note 2	Revised in its entirety
20	PG-27.4, Note 6	In-text table revised
34	Fig. PG-36.4	(1) Sketch (e) revised (2) Sketches (e-1) and (e-2) added (3) General note added
37	Table PG-39	Revised per errata
55	PG-61.2	Revised
56	PG-67.4.1	(1) Second paragraph revised (2) New third paragraph added
59	PG-67.5	Second paragraph revised
66	PG-73.3.5	Deleted
75	PG-106.8	New PG-106.8 heading added
	PG-106.8.1	Redesignated from PG-106.8
	PG-106.8.2	Added
77	PG-110	Revised
84, 85	PW-9.3	Revised
	PW-9.3.1	Revised in its entirety
	PW-9.3.3	Deleted
	PW-11.3	Revised in its entirety
86	Table PW-11	General Notes (a) and (e) revised

<i>Page</i>	<i>Location</i>	<i>Change</i>
93	Fig. PW-16.1, sketch (bb)	Added
94	PW-16.6(c)	Added
99, 100, 104, 105	PW-39.1	Revised
	PW-39.2.1	Revised
	PW-39.3	Revised
	Table PW-39	Note (3) revised
	PW-39.4.3	Revised in its entirety
	PW-39.4.3.1	Added
	PW-39.4.3.2	Added
	PW-39.4.3.2.1	Added
	PW-39.5	Revised in its entirety
	PW-39.5.1	Added
	PW-39.5.1.1	Added
	PW-39.5.1.2	Added
107, 108	PW-39.5.2	Added
	PW-39.5.3	Added
	PW-39.6	Revised in its entirety
	PW-40	Title revised
	PW-40.1	Revised
	PW-40.2	Revised
	PW-40.3	Added
	PW-40.3.1	Added
	PW-40.3.2	Added
	PW-40.3.2.1	Added
	PW-40.3.2.2	Added
	PW-40.3.3	Added
	PW-40.3.4	Added
	PW-40.3.5	Added
	PW-40.3.6	Added
	PW-40.3.7	Added
	PW-40.3.8	Added
	PW-40.3.9	Added
113	PW-51.5	Revised
	Footnote 3	Revised
114	PW-52.4	Revised
135	PWT-15	Revised in its entirety
145	PFT-21.3	Revised
152	PFT-42	(1) Title revised (2) Revised in its entirety
184	A-22.6.3.2.1	Equation revised
185	A-22.6.3.2.4	Equation revised

<i>Page</i>	<i>Location</i>	<i>Change</i>
202	A-125	Second equation revised
205	A-260.3	Second paragraph revised
	A-260.4(d)	Deleted
206	A-270.3	First paragraph revised
	A-270.4(d)	Deleted
238	A-354.1	Numbers 4 and 4a revised
240	A-354.2	Numbers 4 and 4a revised
249	Table A-360	Revised
258	SI Units	Paragraph editorially revised

NOTE:

Volume 48 of the Interpretations to Section I of the ASME Boiler and Pressure Vessel Code follows the last page of the this Edition to Section I.

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PART PG

GENERAL REQUIREMENTS FOR ALL METHODS OF CONSTRUCTION

GENERAL

PG-1 SCOPE

The requirements of Part PG apply to power boilers and high pressure, high-temperature water boilers and to parts and appurtenances thereto and shall be used in conjunction with the specific requirements in the applicable Parts of this Section that pertain to the methods of construction used.

PG-2 SERVICE LIMITATIONS

PG-2.1 The rules of this Section are applicable to the following services:

- (a) boilers in which steam or other vapor is generated at a pressure of more than 15 psig (103 kPa);
- (b) high-temperature water boilers intended for operation at pressures exceeding 160 psig (1 100 kPa) and/or temperatures exceeding 250°F (121°C).

PG-2.2 For services below those specified in PG-2.1 it is intended that rules of Section IV apply; however, boilers for such services may be constructed and stamped in accordance with this Section provided all applicable requirements are met.

PG-2.3 Coil-type hot water boilers where the water can flash into steam when released directly to the atmosphere through a manually operated nozzle may be exempted from the rules of this Section provided the following conditions are met.

- (a) There is no drum, header, or other steam space.
- (b) No steam is generated within the coil.
- (c) Tubing outside diameter does not exceed 1 in. (25 mm).
- (d) Pipe size does not exceed NPS $\frac{3}{4}$ (DN 20).
- (e) Nominal water capacity does not exceed 6 gal (23 l).
- (f) Water temperature does not exceed 350°F (177°C).

(g) Adequate safety relief valves and controls are provided.

PG-3 REFERENCED STANDARDS

Specific editions of standards referenced in this Section are shown in Appendix A-360.

MATERIALS

PG-5 GENERAL

PG-5.1 Material subject to stress due to pressure shall conform to one of the specifications given in Section II and shall be limited to those that are listed in the Tables of Section II, Part D, except as otherwise permitted in PG-8.2, PG-8.3, PG-10, and PG-11. Materials shall not be used at temperatures above those for which stress values are limited, for Section I construction, in the Tables of Section II, Part D. Specific additional requirements described in PG-5 through PG-13 shall be met as applicable.

PG-5.2 Material covered by specifications in Section II is not restricted as to the method of production unless so stated in the specification, and as long as the product complies with the requirements of the specification.

PG-5.3 If, in the development of the art of boiler construction, it is desired to use materials other than those herein described, data should be submitted to the Boiler and Pressure Vessel Committee in accordance with the requirements of Appendix 5 of Section II, Part D. Material not completely identified with any approved Code specifications may be used in the construction of boilers under the conditions outlined in PG-10.

PG-5.4 Materials outside the limits of size or thickness given in the title or scope clause of any specification

in Section II may be used if the material is in compliance with the other requirements of the specification, and no similar limitation is given in the rules for construction.

PG-5.5 The use of austenitic alloy steel is permitted for boiler pressure parts that are steam touched in normal operation. Except as specifically provided in PG-9.1.1, PG-12, and PEB-5.3, the use of such austenitic alloys for boiler pressure parts that are water wetted in normal service is prohibited.¹

PG-6 PLATE

- 01 PG-6.1** Steel plates for any part of a boiler subject to pressure, whether or not exposed to the fire or products of combustion, shall be of pressure vessel quality in accordance with one of the following specifications:

SA-202 Pressure Vessel Plates, Alloy Steel, Chromium-Manganese-Silicon

SA-204 Pressure Vessel Plates, Alloy Steel, Molybdenum

SA-240 (Type 405 only) Pressure Vessel Plates, Alloy Steel (Ferritic Stainless), Chromium

SA-285 Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength

SA-299 Pressure Vessel Plates, Carbon Steel, Manganese-Silicon

SA-302 Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

SA-387 Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum

SA-515 Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

SA-516 Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

SA/EN-10028-2 Flat Products Made of Steels for Pressure Purposes

PG-7 FORGINGS

PG-7.1 Seamless steel drum forgings made in accordance with SA-266 for Carbon-Steel and SA-336 for

¹ Austenitic alloys are susceptible to intergranular corrosion and stress corrosion cracking when used in boiler applications in water wetted service. Factors that affect the sensitivity to these metallurgical phenomena are applied or residual stress and water chemistry. Susceptibility to attack is usually enhanced by using the material in a stressed condition with a concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species). For successful operation in water environments, residual and applied stresses must be minimized and careful attention must be paid to continuous control of water chemistry.

Alloy Steel may be used for any part of a boiler for which pressure vessel quality is specified or permitted.

PG-7.2 Forged flanges, fittings, nozzles, valves, and other pressure parts of the boiler shall be of material that conforms to one of the forging specifications as listed in PG-9.

PG-7.3 Drums, shells, or domes may be of seamless drawn construction, with or without integral heads, provided the material conforms to the requirements of the Code for shell material.

PG-8 CASTINGS

PG-8.1 Except for the limited usage permitted by PG-8.2 and PG-8.3, cast material used in the construction of vessels and vessel parts shall conform to one of the specifications listed in PG-9 for which maximum allowable stress values are given in Tables 1A and 1B of Section II, Part D. The allowable stress values shall be multiplied by the applicable casting quality factor given in PG-25 for all cast materials except cast iron.

When cast iron is used as allowed in PG-11.1 for standard pressure parts, it shall conform to one of these standards:

ASME B16.1, Cast Iron Pipe Flanges and Flanged Fittings

ASME B16.4, Cast Iron Threaded Fittings

Material conforming to ASTM A 126 may be used subject to all requirements of the particular standard. Such usage is subject also to all the requirements for the use of cast iron given in PG-8.2 and other paragraphs of this Section.

PG-8.2 Cast Iron

PG-8.2.1 Cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature.

PG-8.2.2 Cast iron as designated in SA-278, Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (343°C) may be used for boiler and superheater connections under pressure, such as pipe fittings, water columns, valves and their bonnets, for pressures up to 250 psi (1 720 kPa), provided the steam temperature does not exceed 450°F (232°C).

PG-8.3 Cast Nodular Iron. Cast nodular iron as designated in SA-395 may be used for boiler and superheater connections under pressure, such as pipe fittings, water columns, and valves and their bonnets, for pressures not to exceed 350 psi (2 410 kPa), provided the steam temperature does not exceed 450°F (232°C).

PG-8.4 Nonferrous. Bronze castings shall conform to SB-61 and SB-62 and may be used only for the following:

PG-8.4.1 For flanges and flanged or threaded fittings complying with the pressure and temperature requirements of ANSI B16.15 or B16.24, except that such fittings shall not be used where steel or other material is specifically required. Threaded fittings shall not be used where flanged types are specified.

PG-8.4.2.1 For valves at allowable stress values not to exceed those given in Table 1B of Section II, Part D, with maximum allowable temperatures of 550°F (288°C) for SB-61 and 406°F (208°C) for SB-62.

PG-8.4.2.2 For parts of safety valves or safety relief valves subject to limitations of PG-67.7.

PG-9 PIPES, TUBES, AND PRESSURE CONTAINING PARTS

Pipes, tubes, and pressure containing parts used in boilers shall conform to one of the specifications listed in this paragraph for which maximum allowable stresses are given in Tables 1A and 1B of Section II, Part D. The stress values given in these tables include the applicable joint efficiency factor for welded pipes and tubes.

Open-hearth, electric furnace, or basic oxygen steel shall be used for boiler pressure parts exposed to the fire or products of combustion. When used for internal pressure, the material stress and dimensions shall meet the appropriate requirements of PG-27 and Part PW and be in accordance with the following:

01 PG-9.1 Boiler parts shall be of the following specifications only:

- SA-53 Welded and Seamless Steel Pipe (excluding galvanized)
- SA-105 Forgings, Carbon Steel, for Piping Components
- SA-106 Seamless Carbon Steel Pipe for High-Temperature Service
- SA-178 Electric-Resistance-Welded Carbon Steel Boiler Tubes
- SA-181 Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service
- SA-182 Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service (ferritic only)
- SA-192 Seamless Carbon Steel Boiler Tubes for High Pressure Service

SA-209 Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes

SA-210 Seamless Medium Carbon Steel Boiler and Superheater Tubes

SA-213 Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater and Heat Exchanger Tubes (ferritic only)

SA-216 Carbon Steel Castings Suitable for Fusion Welding for High-Temperature Service

SA-217 Alloy-Steel Castings for Pressure-Containing Parts Suitable for High-Temperature Service

SA-234 Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

SA-250 Electric-Resistance-Welded Carbon-Molybdenum Alloy Steel Boiler and Superheater Tubes

SA-266 Carbon Steel Seamless Drum Forgings

SA-268 Seamless and Welded Ferritic Stainless Steel Tubing for General Service

SA-335 Seamless Ferritic Alloy Steel Pipe for High-Temperature Service

SA-336 Alloy Steel Seamless Drum Forgings (ferritic only)

SA-423 Seamless and Electric Welded Low Alloy Steel Tubes

SA-660 Centrifugally Cast Carbon Steel Pipe for High-Temperature Service

SA-731 Seamless, Welded Ferritic, and Martensitic Stainless Steel Pipe

PG-9.1.1 Boiler parts on once-through boilers shall be any of the specifications listed in PG-9.1 or any of the following²:

SB-407 Nickel-Iron-Chromium Alloy Seamless Pipe and Tube

SB-408 Nickel-Iron-Chromium Alloy Rod and Bar

SB-409 Nickel-Iron-Chromium Alloy Plate, Sheet, and Strip

SB-423 Nickel-Iron-Chromium-Molybdenum Seamless Pipe and Tube

SB-424 Nickel-Iron-Chromium-Molybdenum-Copper Alloy Plate, Sheet, and Strip

SB-425 Nickel-Iron-Chromium-Molybdenum-Copper Alloy Rod and Bar

SB-515 Welded Nickel-Iron-Chromium Alloy Tubes

SB-564 Nickel Alloy Forgings

PG-9.2 Superheater parts shall be of any one of the specifications listed in PG-9.1 or one of the following:

SA-182 Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Plates for High-Temperature Service

² The maximum recommended feedwater-dissolved solids concentration for once-through boilers is 0.050 ppm.

SA-213 Seamless Ferritic and Austenitic Alloy Steel Boiler, Superheater and Heat Exchanger Tubes
 SA-240 Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plates, Sheet and Strip for Fusion-Welded Unfired Pressure Vessels
 SA-249 Welded Austenitic Steel Boiler, Superheater, Heat Exchanger, and Condenser Tubes
 SA-312 Seamless and Welded Austenitic Stainless Steel Pipe
 SA-336 Alloy Steel Seamless Drum Forgings
 SA-351 Ferritic and Austenitic Steel Castings for High-Temperature Service
 SA-369 Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service
 SA-376 Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service
 SA-430 Austenitic Steel Forged and Bored Pipe for High-Temperature Service
 SA-479 Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
 SA-731 Seamless, Welded Ferritic, and Martensitic Stainless Steel Pipe
 SB-163 Seamless Nickel and Nickel Alloy Condenser and Heat Exchanger Tubes
 SB-166 Nickel-Chromium Iron Alloys (UNS N06600, N06601, N06690, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Rod, Bar, and Wire
 SB-167 Nickel-Chromium Iron Alloys (UNS N06600, N06601, N06690, N06025, and N06045) Seamless Pipe and Tube
 SB-168 Nickel-Chromium Iron Alloys (UNS N06600, N06601, N06690, N06026, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip
 SB-366 Factory-Made Wrought Nickel and Nickel Alloy Fittings
 SB-407 Nickel-Iron-Chromium Alloy Seamless Pipe and Tube
 SB-408 Nickel-Iron-Chromium Alloy Rod and Bar
 SB-409 Nickel-Iron-Chromium Alloy Plate, Sheet, and Strip
 SB-423 Nickel-Iron-Chromium-Molybdenum Seamless Pipe and Tube
 SB-424 Nickel-Iron-Chromium-Molybdenum-Copper Alloy Plate, Sheet, and Strip
 SB-425 Nickel-Iron-Chromium-Molybdenum-Copper Alloy Rod and Bar
 SB-435 N06002, W06230, and R30556 Plate, Sheet, and Strip
 SB-514 Welded Nickel-Iron-Chromium Alloy Pipe
 SB-515 Welded Nickel-Iron-Chromium Alloy Tubes

SB-516 Welded Nickel-Chromium-Iron Alloy (UNS N06600), UNS N06025, and UNS N06045 Tubes
 SB-517 Welded Nickel-Chromium-Iron Alloy (UNS N06600), UNS N06025, and UNS N06045 Pipe
 SB-564 Nickel Alloy Forgings
 SB-572 Nickel-Molybdenum-Chromium-Iron Alloy Rod
 SB-619 Welded Nickel and Nickel-Cobalt Alloy Pipe
 SB-622 Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube
 SB-626 Welded Nickel and Nickel-Cobalt Alloy Tube

PG-9.3 Copper or copper alloy pipe or tubes shall not be used in the boiler proper for any service where the temperature exceeds 406°F (208°C). Copper and copper alloys shall be seamless, having a thickness not less than ANSI Schedule 40 standard pipe, and shall comply to one of the following specifications: SB-42, Seamless Copper Pipe, Standard Sizes; SB-43, Seamless Red Brass Pipe, Standard Sizes; SB-75, Seamless Copper Tube; or SB-111, Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock.

PG-9.4 Bimetallic tubes, having a core of an acceptable boiler and superheater material, and having an external cladding of another metal alloy, may be used provided the requirements of PG-27.2.1.5 are met for establishing minimum thickness of the core. The permissible variation in wall thickness tolerance of SA-450 or SB-163, as applicable, shall apply to the total wall thickness. The thickness and over and undertolerances of the cladding shall be included in the ordering information. Marking of the bimetallic tubular product shall meet the specification requirements of the core material, but shall also suitably identify the cladding alloy.

PG-9.5 ERW products shall be limited to a maximum thickness of $\frac{1}{2}$ in. for internal pressure applications. For external pressure applications, ERW products shall be limited to a maximum thickness of $\frac{1}{2}$ in. and a maximum size of NPS 24. The thickness and diameter limitations noted above shall be within tolerances stated by the product material specification.

PG-10 MATERIAL IDENTIFIED WITH OR PRODUCED TO A SPECIFICATION NOT PERMITTED BY THIS SECTION, AND MATERIAL NOT FULLY IDENTIFIED

PG-10.1 Identified With Complete Certification From the Material Manufacturer. Material identified with a specification not permitted by this Section, or material procured to chemical composition requirements

and identified to a single production lot as required by a permitted specification may be accepted as satisfying the requirements of a specification permitted by this Section provided the conditions set forth in PG-10.1.1 or PG-10.1.2 are satisfied.

PG-10.1.1 Recertification by an organization other than the boiler or part manufacturer:

PG-10.1.1.1 All requirements, including but not limited to, melting method, melting practice, deoxidation, quality, and heat treatment, of the specification permitted by this Section, to which the material is to be recertified, have been demonstrated to have been met.

PG-10.1.1.2 A copy of the certification by the material manufacturer of the chemical analysis required by the permitted specification, with documentation showing the requirements to which the material was produced and purchased, and which demonstrates that there is no conflict with the requirements of the permitted specification, has been furnished to the boiler or part manufacturer.

PG-10.1.1.3 A certification that the material was manufactured and tested in accordance with the requirements of the specification to which the material is recertified, excluding the specific marking requirements, has been furnished to the boiler or part manufacturer, together with copies of all documents and test reports pertinent to the demonstration of conformance to the requirements of the permitted specification.

PG-10.1.1.4 The material, and the Certificate of Compliance or the Material Test Report have been identified with the designation of the specification to which the material is recertified and with the notation "Certified per PG-10."

PG-10.1.2 Recertification by the boiler or part manufacturer:

PG-10.1.2.1 A copy of the certification by the material manufacturer of the chemical analysis required by the permitted specification, with documentation showing the requirements to which the material was produced and purchased, which demonstrates that there is no conflict with the requirements of the permitted specification, is available to the Inspector.

PG-10.1.2.2 For applications in which the maximum allowable stresses are subject to a note of Table 1A of Section II, Part D, requiring the use of killed steel, documentation is available to the Inspector that establishes that the material is a killed steel.

PG-10.1.2.3 Documentation is available to the Inspector that demonstrates that the metallurgical structure, mechanical property, and hardness requirements of the permitted specification have been met.

PG-10.1.2.4 For material recertified to a permitted specification that requires a fine austenitic grain size or that requires that a fine grain practice be used during melting, documentation is available to the Inspector that demonstrates that the heat treatment requirements of the permitted specification have been met, or will be met during fabrication.

PG-10.1.2.5 The material has marking, acceptable to the Inspector, for identification to the documentation.

PG-10.1.2.6 When the conformance of the material with the permitted specification has been established, the material has been marked as required by the permitted specification.

PG-10.2 Material Identified to a Particular Production Lot as Required by a Specification Permitted by This Section but That Cannot Be Qualified Under PG-10.1. Any material identified to a particular production lot as required by a specification permitted by this Section, but for which the documentation required in PG-10.1 is not available, may be accepted as satisfying the requirements of the specification permitted by this Section provided that the conditions set forth below are satisfied.

PG-10.2.1 Recertification by an organization other than the boiler or part manufacturer — not permitted.

PG-10.2.2 Recertification by the boiler or part manufacturer.

PG-10.2.2.1 Chemical analyses are made on different pieces from the lot to establish a mean analysis which is to be accepted as representative of the lot. The pieces chosen for analyses shall be selected at random from the lot. The number of pieces selected shall be at least 10% of the number of pieces in the lot, but not less than three. For lots of three pieces or less, each piece shall be analyzed. Each individual analysis in the permitted specification and the mean for each element shall conform to the heat analysis limits of that specification. Analyses need to be made for only those elements required by the permitted specification. However, consideration should be given to making analyses for elements not specified in the specification but which would be deleterious if present in excessive amounts.

PG-10.2.2.2 Mechanical property tests are made in accordance with the requirements of the permitted specification and the results of the tests conform to the specified requirements.

PG-10.2.2.3 For applications in which the maximum allowable stresses are subject to a note of Table 1A of Section II, Part D, requiring the use of killed steel, documentation is available to the Inspector which establishes that the material is a killed steel.

PG-10.2.2.4 When the requirements of the permitted specification include metallurgical structure requirements (i.e., fine austenitic grain size), tests are made and the results are sufficient to establish that those requirements of the specification have been met.

PG-10.2.2.5 When the requirements of the permitted specification include heat treatment, the material is heat treated in accordance with those requirements, either prior to or during fabrication.

PG-10.2.2.6 When the conformance of the material with the permitted specification has been established, the material has been marked as required by the permitted specification.

PG-10.3 Material Not Fully Identified. Material which cannot be qualified under the provisions of either PG-10.1 or PG-10.2, such as material not fully identified as required by the permitted specification or as unidentified material, may be accepted as satisfying the requirements of a specification permitted by this Section provided that the conditions set forth below are satisfied.

PG-10.3.1 Qualification by an organization other than the boiler or part manufacturer — not permitted.

PG-10.3.2 Qualification by the boiler or part manufacturer:

PG-10.3.2.1 Each piece is tested to show that it meets the chemical composition for product analysis and the mechanical properties requirements of the permitted specification. Chemical analyses need only be made for those elements required by the permitted specification. However, consideration shall be given to making analyses for elements not specified in the specification but which would be deleterious if present in excessive amounts. For plates, when the direction of final rolling is not known, both a transverse and a longitudinal tension test specimen shall be taken from each sampling location designated in the permitted specification. The results of both tests shall conform to the minimum requirements of the specification, but

the tensile strength of only one of the two specimens need conform to the maximum requirement.

PG-10.3.2.2 The provisions of PG-10.2.2.3, PG-10.2.2.4, and PG-10.2.2.5 are met.

PG-10.3.2.3 When the identity of the material with the permitted specification has been established in accordance with PG-10.3.2.1 and PG-10.3.2.2, each piece (or bundle, etc., if permitted in the specification) is marked with a marking giving the permitted specification number and grade, type, or class as applicable and a serial number identifying the particular lot of material. A suitable report, clearly marked as being a “Report on Tests of Nonidentified Material,” shall be completed and certified by the boiler or part manufacturer. This report, when accepted by the Inspector, shall constitute authority to use the material in lieu of material procured to the requirements of the permitted specification.

PG-11 MISCELLANEOUS PRESSURE PARTS

Prefabricated or preformed pressure parts for boilers which are subject to allowable working stresses due to internal or external pressure in the boiler and which are furnished by other than the shop of the Manufacturer responsible for the completed boiler shall conform to all applicable requirements of the Code for the completed boiler, including inspection in the shop of the parts manufacturer and the furnishing of Manufacturer’s Partial Data Reports as provided for in PG-112.2.4 except as permitted in PG-11.1, PG-11.2, and PG-11.3.

PG-11.1 Cast, Forged, Rolled, or Die Formed Standard Pressure Parts

PG-11.1.1 Pressure parts such as pipe fittings, valves, flanges, nozzles, welding necks, welding caps, manhole frames and covers, and casings of pumps that are part of a boiler circulating system that are wholly formed by casting, forging, rolling, or die forming shall not require inspection, mill test reports, or Partial Data Reports. Standard pressure parts that comply with some ASME Standard³ shall be made of materials permitted by this Section or of materials specifically listed in an ASME product standard listed elsewhere in this Section but not of materials specifically prohibited or beyond use limitations listed in this Section. Standard pressure

³These are pressure parts that comply with some ASME product standard accepted by reference in PG-42. The ASME product standard establishes the basis for the pressure–temperature rating and marking.

parts that comply with a manufacturer's standard^{4,5} shall be made of materials permitted by this Section. Such parts shall be marked with the name or trademark of the parts manufacturer and such other markings as are required by the standard. Such markings shall be considered as the parts manufacturer's certification that the product complies with the material specifications and standards indicated and is suitable for service at the rating indicated. The intent of the paragraph will have been met if, in lieu of the detailed marking on the part itself, the parts described herein have been marked in any permanent or temporary manner that will serve to identify the part with the parts manufacturer's written listing of the particular items and such listings are available for examination by the Inspector.

PG-11.1.2 Parts of small size falling within this category for which it is difficult or impossible to obtain identified material or that may be stocked and for which mill test reports or certificates cannot be economically obtained and are not customarily furnished, and that do not appreciably affect the safety of the vessel, may be used for relatively unimportant part or parts stressed to not more than 50% of the stress value permitted by this Section, and listed in Tables 1A and 1B of Section II, Part D, provided they are suitable for the purpose intended and meet the approval of the Inspector. The Manufacturer of the completed vessel shall satisfy himself that the part is suitable for the design conditions specified for the completed vessel.

PG-11.2 Cast, Forged, Rolled, or Die Formed Nonstandard Pressure Parts. Pressure parts such as shells, heads, removable and access opening cover plates, that are wholly formed by casting, forging, rolling, or die forming, may be supplied basically as materials. All such parts shall be made of materials permitted under this Section, and the manufacturer of the part shall furnish mill test reports or other acceptable evidence to that effect. Such parts shall be marked with the name or trademark of the parts manufacturer and with such other markings as will serve to identify the particular parts with accompanying material identification. The Manufacturer of the completed boiler shall satisfy himself that the part is suitable for the design conditions specified for the completed boiler.

⁴These are pressure parts that comply with a parts manufacturer's standard that defines the pressure-temperature rating marked on the part and described in the parts manufacturer's literature. The Manufacturer of the completed vessel shall satisfy himself that the part is suitable for the design conditions of the completed vessel.

⁵Pressure parts may be in accordance with an ASME product standard not covered by footnote 4, but such parts shall satisfy the requirements applicable to a parts manufacturer's standard and footnote 6.

PG-11.3 Welded Standard Pressure Parts for Use Other Than the Shell of a Vessel.⁶ Pressure parts such as welded standard pipe fittings, caps, valves, and flanges that are fabricated by one of the welding processes recognized by this Section shall not require inspection, mill test reports, or Manufacturers' Partial Data Reports provided.⁷

PG-11.3.1 Standard pressure parts that comply with some ASME product standard⁴ shall be made of materials permitted by this Section or of materials specifically listed in an ASME product standard accepted and listed elsewhere in this Section but not of materials specifically prohibited or beyond use limitations listed in this Section. Standard pressure parts that comply with a manufacturer's standard^{4,5} shall be made of materials permitted by this Section.

PG-11.3.2 Welding for pressure parts that comply with a manufacturer's standard^{4,5} shall comply with the requirements of PW-26 through PW-39. Welding for pressure parts that comply with some ASME product standard³ shall comply with the requirements of PW-26 through PW-39 or, as a minimum, may comply with the welding requirements of SA-234. Markings where applicable, or certification by the parts manufacturer where markings are not applicable shall be accepted as evidence of compliance with the above welding requirements. Such parts shall be marked as required by PG-11.1.1.

PG-11.3.3 If radiographic examination or heat treatment is required by the applicable rules of this Section, it may be performed either in the plant of the parts manufacturer or in the plant of the Manufacturer of the completed vessel.

If the radiographic examination is done under the control of the parts manufacturer, the completed radiographs, properly identified, with a radiographic inspection report, shall be forwarded to the vessel manufacturer and shall be available to the Authorized Inspector.

PG-11.3.4 If heat treatment is performed at the plant of the parts manufacturer, certification by the parts manufacturer that such treatment was performed shall be accepted as evidence of compliance with applicable Code paragraphs. This certification shall be available to the Authorized Inspector. The Manufacturer of the completed vessel shall satisfy himself that the

⁶Fusion welded pipe, with added filler metal, for use as the shell of the vessel shall be subject to the same requirements as a shell fabricated from plate, including inspection at the point of manufacture and Manufacturers' Partial Data Reports.

⁷For requirements for welded water columns, see PW-42.

part is suitable for the design conditions specified for the completed vessel.

PG-12 GAGE GLASS BODY AND CONNECTOR MATERIALS

Gage glass body and connector materials shall comply with a Manufacturer's standard that defines the pressure-temperature rating marked on the unit. The materials used may include austenitic stainless steel.

PG-13 STAYS

Threaded stays shall be of steel complying with SA-36 or SA-675.

Seamless steel tubes for threaded stays shall comply with SA-192 or SA-210.

Staybolts, stays, through-rods, or stays with ends for attachment by fusion welding shall comply with SA-36 or SA-675.

DESIGN

PG-16 GENERAL

PG-16.1 The design of power boilers, high-temperature water boilers, and other pressure parts included within the scope of these rules shall conform to the general design requirements in the following paragraphs and in addition to the specific requirements for design given in the applicable Parts of this Section that pertain to the methods of construction used.

PG-16.2 When the pressure parts of a forced-flow steam generator with no fixed steam and waterline are designed for different pressure levels as permitted in PG-21.2, the owner shall provide or cause to be provided a boiler pressure system design diagram, certified by a Professional Engineer experienced in the mechanical design of power plants, which supplies the following information.

PG-16.2.1 The relative location of the various pressure parts within the scope of Section I, with respect to the path of water-steam flow.

PG-16.2.2 A line showing the expected maximum sustained pressure as described in PG-21.2, indicating the expected variation in pressure along the path of water-steam flow.

PG-16.2.3 The maximum allowable working pressure of the various pressure parts.

PG-16.2.4 The location and set pressure of the overpressure protection devices.

Copy of this diagram shall be attached to the Master Data Report per PG-113.

PG-16.3 Minimum Thicknesses. The minimum thickness of any boiler plate under pressure shall be $\frac{1}{4}$ in. (6 mm) except for electric boilers constructed under the rules of Part PEB. The minimum thickness of plates to which stays may be applied in other than cylindrical outer shell plates shall be $\frac{5}{16}$ (8 mm) in. When pipe over NPS 5 (DN 125) is used in lieu of plate for the shell of cylindrical components under pressure, its minimum wall shall be $\frac{1}{4}$ in. (6 mm).

PG-16.4 Undertolerance on Plates. Plate material that is not more than 0.01 in. (0.3 mm) thinner than that calculated from the formula may be used in Code constructions provided the material specification permits such plate to be furnished not more than 0.01 in. (0.3 mm) thinner than ordered.

PG-16.5 Undertolerance on Pipe and Tubes. Pipe or tube material shall not be ordered thinner than that calculated from the applicable formula of this Section. The ordered material shall include provision for the allowed manufacturing undertolerance as given in Section II in the applicable pipe or tube specification.

PG-17 FABRICATION BY A COMBINATION OF METHODS

A boiler and parts thereof may be designed and fabricated by a combination of the methods of fabrication given in this Section, provided the rules applying to the respective methods of fabrication are followed and the boiler is limited to the service permitted by the method of fabrication having the most restrictive requirements.

PG-18 HYDROSTATIC DEFORMATION TEST

Where no rules are given and it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the Manufacturer and tested in accordance with the Standard Practice for Making a Hydrostatic Test on a Boiler Pressure Part to Determine the Maximum Allowable Working Pressure, given in A-22 or in such other manner as the Committee may prescribe.

TABLE PG-19 POST COLD-FORMING STRAIN LIMITS AND HEAT-TREATMENT REQUIREMENTS

Limitations in Lower Temperature Range							Limitations in Higher Temperature Range			Minimum Heat-Treatment Temperature When Design Temperature and Forming Strain Limits are Exceeded [Notes (1) and (2)]	
for Design Temperature											
		Exceeding		But Less Than or Equal to		And Forming Strains Exceeding	For Design Temperature Exceeding		And Forming Strains Exceeding		
Grade	UNS Number	°F	°C	°F	°C		°F	°C		°F	°C
304	S30400	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	1,900	(1 038)
304H	S30409	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	1,900	(1 038)
304N	S30451	1,075	(579)	1,250	(676)	15%	1,250	(676)	10%	1,900	(1 038)
309S	S30908	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	2,000	(1 093)
310H	S31009	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	2,000	(1 093)
310S	S31008	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	2,000	(1 093)
316	S31600	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	1,900	(1 038)
316H	S31609	1,075	(579)	1,250	(676)	20%	1,250	(676)	10%	1,900	(1 038)
316N	S31651	1,075	(579)	1,250	(676)	15%	1,250	(676)	10%	1,900	(1 038)
321	S32100	1,000	(538)	1,250	(676)	15% [Note (3)]	1,250	(676)	10%	1,900	(1 038)
321H	S32109	1,000	(538)	1,250	(676)	15% [Note (3)]	1,250	(676)	10%	2,000	(1 038)
347	S34700	1,000	(538)	1,250	(676)	15%	1,250	(676)	10%	1,900	(1 038)
347H	S34709	1,000	(538)	1,250	(676)	15%	1,250	(676)	10%	2,000	(1 093)
348	S34800	1,000	(538)	1,250	(676)	15%	1,250	(676)	10%	1,900	(1 038)
348H	S34809	1,000	(538)	1,250	(676)	15%	1,250	(676)	10%	2,000	(1 093)
800	N08800	1,100	(593)	1,250	(676)	15%	1,250	(676)	10%	1,800	(982)
800H	N08810	1,100	(593)	1,250	(676)	15%	1,250	(676)	10%	2,050	(1 121)

GENERAL NOTE: The limits shown are for cylinders formed from plates, spherical or dished heads formed from plate, and tube and pipe bends. For flares, swages, and upsets, the forming strain limits shall be half those tabulated in this Table. When the forming strains cannot be calculated as shown in PG-19, the forming strain limits shall be half those tabulated in this Table (see PG-19.1).

NOTES:

(1) Rate of cooling from heat-treatment temperature not subject to specific control limits.

(2) While minimum heat-treatment temperatures are specified, it is recommended that the heat-treatment temperature range be limited to 150°F (83°C) above that minimum [250°F (139°C) temperature range for 347, 347H, 348, and 348H].

(3) For simple bends of tubes or pipes whose outside diameter is less than 3.5 in., this limit is 20%.

01 PG-19 COLD FORMING OF AUSTENITIC MATERIALS⁸

The cold formed areas of pressure-retaining components manufactured of austenitic alloys shall be heat treated for twenty minutes per inch of thickness or for ten minutes, whichever is greater, at the temperatures given in Table PG-19 under the following conditions:

(a) The finishing-forming temperature is below the minimum heat-treating temperature given in Table PG-19; and

(b) The design metal temperature and the forming strains exceed the limits shown in Table PG-19.

Forming strains shall be calculated as follows:

(a) Cylinders formed from plate:

$$\%Strain = \frac{50t}{R_f} \left(1 - \frac{R_f}{R_o} \right)$$

(b) Spherical or dished heads formed from plate:

$$\%Strain = \frac{75t}{R_f} \left(1 - \frac{R_f}{R_o} \right)$$

(c) Tube and pipe bends; the larger of:

$$\%Strain = \frac{100r}{R}$$

⁸ See Section II, Part D, Appendix 6, para. 6-460, for background on the rules in PG-19.

or:

$$\%Strain = \left(\frac{t_A - t_B}{t_A} \right) 100$$

(d) Tube or pipe flares, swages, or upsets (see Fig. PG-19); the larger of either the O.D. or I.D. hoop strain, the axial strain, or the radial strain. The absolute value of the largest strain is to be used as the basis for evaluation.

O.D. hoop strain:

$$\%Strain = \frac{(D - D_f)}{D} 100$$

I.D. hoop strain:

$$\%Strain = \frac{(d - d_f)}{d} 100$$

Axial strain:

$$\%Strain = \frac{(L - L_f)}{L} 100$$

Radial strain:

$$\%Strain = \frac{(t - t_f)}{t} 100$$

where

- D = original O.D. of the pipe or tube
- D_f = O.D. of the pipe or tube after forming
- d = original I.D. of the pipe or tube
- d_f = I.D. of the pipe or tube after forming
- L = original length of the "constant volume process zone" for the tube or pipe in flaring, swaging, or upsetting forming operations
- L_f = final length of the "constant volume process zone" for the tube or pipe in flaring, swaging, or upsetting forming operations
- R = nominal bending radius to centerline of pipe or tube
- R_f = mean radius after forming
- R_o = original mean radius (equal to infinity for a flat plate)
- r = nominal outside radius of pipe or tube
- t = nominal thickness of the plate, pipe, or tube before forming
- t_A = measured average wall thickness of pipe or tube
- t_B = measured minimum wall thickness of the extra-dos of the bend
- t_f = nominal thickness of the cylindrical portion after forming

V = volume of the cylindrical process zone prior to forming; $V = (\pi/4)(D^2 - d^2)$

$V = V_f$, i.e., forming is a constant volume process

V_f = volume of the cylindrical process zone after forming; $V_f = (\pi/4)(D_f^2 - d_f^2)$

PG-19.1 When the forming strains cannot be calculated as shown in PG-19, the manufacturer shall have the responsibility to determine the maximum forming strain. In such instances, the forming limits for flares, swages, or upsets in Table PG-19 shall apply.

PG-21 MAXIMUM ALLOWABLE WORKING PRESSURE

The maximum allowable working pressure is the pressure determined by employing the allowable stress values, design rules, and dimensions designated in this Section.

Whenever the term maximum allowable working pressure is used in this Section of the Code, it refers to gage pressure, or the pressure above atmosphere in pounds per square inch.

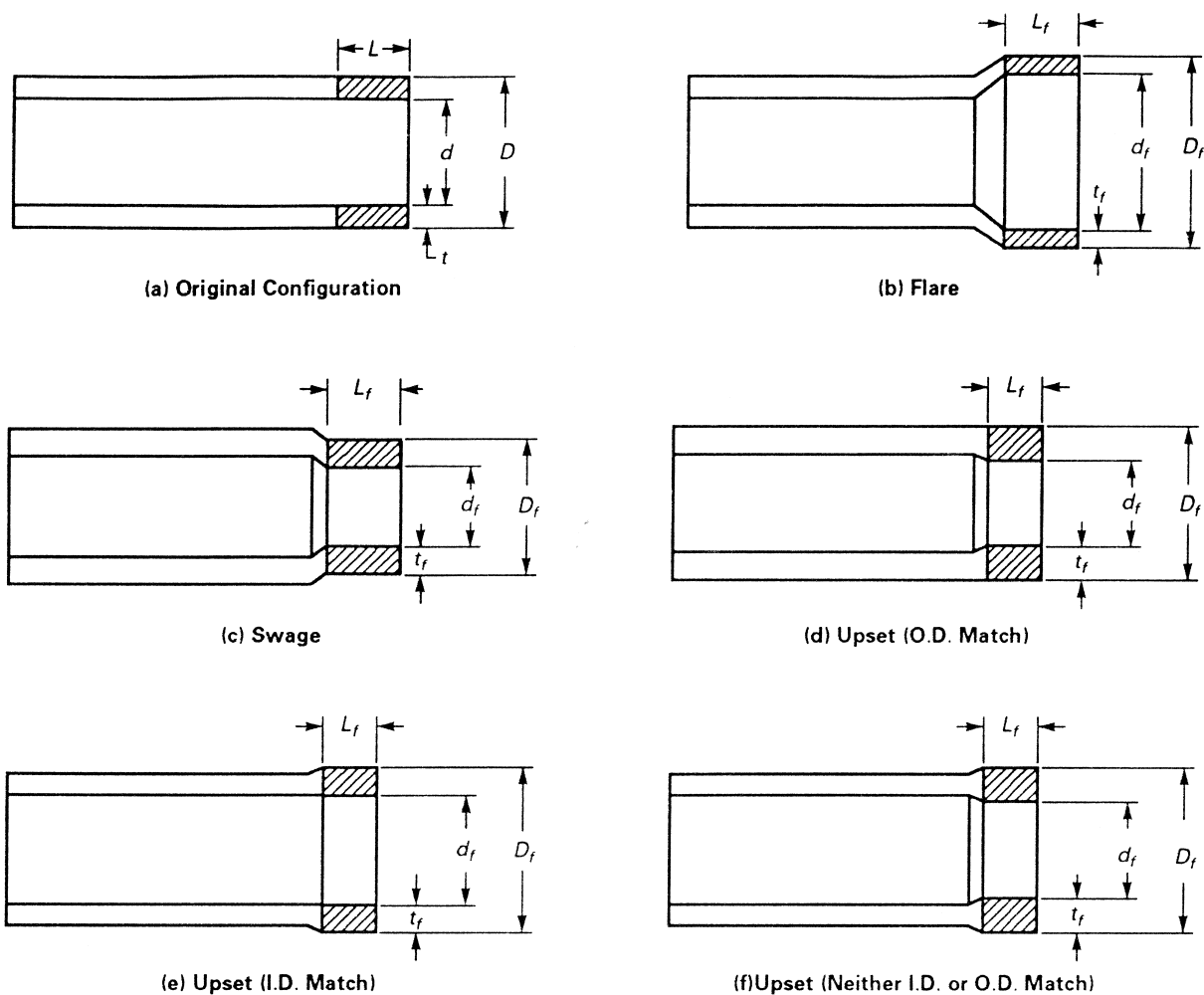
PG-21.1 No boiler, except a forced-flow steam generator with no fixed steam and water line that meets the special provisions of PG-67, shall be operated at a pressure higher than the maximum allowable working pressure except when the safety valve or safety relief valve or valves are discharging, at which time the maximum allowable working pressure shall not be exceeded by more than 6%.

PG-21.2 In a forced-flow steam generator with no fixed steam and waterline it is permissible to design the pressure parts for different pressure levels along the path of water-steam flow. The maximum allowable working pressure of any part shall be not less than that required by the rules of Part PG for the expected maximum sustained conditions⁹ of pressure and temperature to which that part is subjected except when one or more of the overpressure protection devices covered by PG-67.4 is in operation.

PG-22 LOADINGS

PG-22.1 Stresses due to hydrostatic head shall be taken into account in determining the minimum thick-

⁹ "Expected maximum sustained conditions of pressure and temperature" are intended to be selected sufficiently in excess of any expected operating conditions (not necessarily continuous) to permit satisfactory boiler operation without operation of the overpressure protection devices.



 Process Volume for Estimation of Strain

GENERAL NOTE:

$$V = V_f$$

FIG. PG-19 COLD FORMING OPERATIONS FOR FLARING, SWAGING, AND UPSETTING OF TUBING
(The Above Illustrations Are Diagrammatic Only)

ness required unless noted otherwise. Additional stresses imposed by effects other than working pressure or static head that increase the average stress by more than 10% of the allowable working stress shall also be taken into account. These effects include the weight of the component and its contents, and the method of support.

PG-22.2 Loading on structural attachments — refer to PW-43.

PG-23 STRESS VALUES FOR CALCULATION FORMULAS

PG-23.1 The maximum allowable stress values in Tables 1A and 1B of Section II, Part D, are the unit stresses to be used in the formulas of this Section to calculate the minimum required thickness or the maximum allowable working pressure of the pressure part (see Appendix 7 of Section II, Part D).

PG-23.2 The yield strength values for use in PFT-51 may be found in Table Y-1 of Section II, Part D.

PG-25 QUALITY FACTORS FOR STEEL CASTINGS

A quality factor as specified below shall be applied to the allowable stresses for steel casting materials given in Table 1A of Section II, Part D.

PG-25.1 A factor not to exceed 80% shall be applied when a casting is inspected only in accordance with the minimum requirements of the specification for the material, except when the special methods of examination prescribed by the selected specification are followed, thus permitting the use of the applicable higher factor in this paragraph.

PG-25.2 A factor not to exceed 100% shall be applied when the casting meets the following requirements.

PG-25.2.1 All steel castings $4\frac{1}{2}$ in. (114 mm) nominal body thickness or less, other than steel flanges and fittings complying with ASME B16.5, and valves complying with ASME B16.34, shall be inspected as follows:

- 01 PG-25.2.1.1** All critical areas, including the junctions of all gates, risers, and abrupt changes in section or direction and weld-end preparations, shall be radiographed in accordance with Article 2 of Section V, and the radiographs shall conform to the requirements of ASTM E 446, Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness, or

ASTM E 186, Standard Reference Radiographs for Heavy Walled [2 in. to $4\frac{1}{2}$ in. (51 mm to 114 mm)] Steel Castings, depending upon the section thickness. The maximum acceptable severity level for 100% quality factor shall be:

For ASTM E 446 [castings up to 2 in. (51 mm) thickness]:

Imperfection Category	Severity Level	
	Up to and Including 1 in. (25 mm) Thick	Greater Than 1 in. (25 mm) Thick
A	1	2
B	2	3
C Types 1, 2, 3, and 4	1	3
D, E, F, and G	None acceptable	None acceptable

For ASTM E 186 [castings 2 in. to $4\frac{1}{2}$ in. (51 mm to 114 mm) thickness]:

Imperfection Category	Severity Level
A and B, Types 1 and 2 of C	2
Type 3 of C	3
D, E, and F	None acceptable

PG-25.2.1.2 All surfaces of each casting, including machined gasket seating surfaces, shall be examined after heat treatment by the magnetic particle method in accordance with PG-25.2.1.2.1 or by the liquid penetrant method in accordance with PG-25.2.1.2.2.

PG-25.2.1.2.1 The technique for magnetic particle examination shall be in accordance with Article 7 of Section V. Imperfections causing magnetic particle indications exceeding degree 1 of Type I, degree 2 of Type II, and degree 3 of Type III, and exceeding degree 1 of Types IV and V of ASTM E 125, Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings, are unacceptable.

PG-25.2.1.2.2 The technique for liquid penetrant examination shall be in accordance with Article 6 of Section V. Surface indications determined by liquid penetrant examination are unacceptable if they exceed the following:

- (a) all cracks and hot tears;
- (b) any group of more than six linear indications other than those in (a) in any rectangular area of $1\frac{1}{2}$ in. $\times$ 6 in. (38 mm $\times$ 152 mm) or less, or any circular area having a diameter of $3\frac{1}{2}$ in. (89 mm) or less, these areas being taken in the most unfavorable location relative to the indications being evaluated;

(c) other linear indications more than $\frac{1}{4}$ in. (6 mm) long for thicknesses up to $\frac{3}{4}$ in. (19 mm) inclusive, more than one-third of the thickness in length for thicknesses from $\frac{3}{4}$ in. to $2\frac{1}{4}$ in. (19 mm to 57 mm), and more than $\frac{3}{4}$ in. (19 mm) long for thicknesses over $2\frac{1}{4}$ in. (57 mm). (Aligned acceptable indications separated from one another by a distance equal to the length of the longer indication are acceptable.);

(d) all indications of nonlinear imperfections that have any dimension exceeding $\frac{3}{16}$ in. (4.8 mm).

PG-25.2.1.3 Where more than one casting of a particular design is produced, each of the first five castings shall be inspected as above. Where more than five castings are being produced, the examination shall be performed on the first five plus one additional casting to represent each five additional castings. If this additional casting proves to be unacceptable, each of the remaining castings in the group shall be inspected.

PG-25.2.1.4 Any indications in excess of the maximum permitted in PG-25.2.1.1 and PG-25.2.1.2 shall be cause for rejection unless the casting is repaired by welding after the base metal has been inspected to ensure that the imperfection has been removed or reduced to an acceptable size. The completed repair shall be subject to reinspection by the same method as was used in the original inspection and the repaired casting shall be postweld heat treated.

PG-25.2.1.5 All welding shall be performed using welding procedures qualified in accordance with Section IX. The procedure qualification shall be performed on test specimens of cast material of the same specification and subjected to the same heat treatment before and after welding as will be applied to the work. All welders and operators performing this welding shall also be qualified in accordance with Section IX.

PG-25.2.2 All steel castings having a body greater than $4\frac{1}{2}$ in. (114 mm) nominal thickness shall be inspected as follows:

PG-25.2.2.1 All surfaces of each casting, including machined gasket seating surfaces, shall be examined after heat treatment by the magnetic particle method in accordance with PG-25.2.1.2.1 or liquid penetrant method in accordance with PG-25.2.1.2.2.

01 **PG-25.2.2.2** All parts of castings shall be subjected to complete radiographic inspection in accordance with Article 2 of Section V, and the radiographs shall conform to the requirements of ASTM E 280, Standard Reference Radiographs for Heavy Walled [$4\frac{1}{2}$ in. to 12 in. (114 mm to 305 mm)] Steel Castings.

The maximum acceptable severity level for a 100% quality factor shall be:

Imperfection Category	Severity Level
A, B, and Types 1, 2, and 3 of C	2
D, E, and F	None acceptable

PG-25.2.2.3 Any indications in excess of the maximum permitted in PG-25.2.2.1 and PG-25.2.2.2 are unacceptable. The casting may be repaired by welding after the base metal has been magnetic particle or dye penetrant inspected to ensure that the imperfection has been removed or reduced to an acceptable size.

PG-25.2.2.4 All weld repairs of depth exceeding 1 in. (25 mm) or 20% of the section thickness, whichever is less, shall be inspected by radiography in accordance with PG-25.2.2.2 and by magnetic particle or dye penetrant inspection of the finished weld surface. All weld repairs of depth less than 20% of the section thickness, or 1 in. (25 mm), whichever is less, and all weld repairs of sections which cannot be effectively radiographed shall be examined by magnetic particle or dye penetrant inspection of the first layer, of each $\frac{1}{4}$ in. (6 mm) thickness of deposited weld metal and of the finished weld surface. Magnetic particle or dye penetrant testing of the finished weld surface shall be done after postweld heat treatment.

PG-25.2.2.5 When repair welding is done after heat treatment of the casting, the casting shall be postweld heat treated.

PG-25.2.2.6 All welding shall be performed using welding procedures qualified in accordance with Section IX. The procedure qualification shall be performed on test specimens of cast material of the same specification and subjected to the same heat treatment before and after welding as will be applied to the work. All welders and operators performing this welding shall also be qualified in accordance with Section IX.

PG-25.2.3 Identification and Marking. Each casting to which a quality factor greater than 80% is applied shall be marked with the name, trademark, or other traceable identification of the manufacturer and the casting identification, including the casting quality factor and material designation.

PG-25.2.4 Personnel performing radiographic, magnetic particle, or liquid penetrant examinations under this paragraph shall be qualified in accordance with

their employer's written practice. SNT-TC-1A¹⁰ or CP-189 shall be used as a guideline for employers to establish their written practice for qualification and certification of their personnel.

When personnel have been certified according to their employer's written practice based upon an edition of SNT-TC-1A or CP-189 earlier than that referenced in A-360, their certification shall be valid for performing nondestructive examination required by this Section until their next scheduled recertification. Any recertifications, reexaminations, or new examinations shall be performed to the employer's written practice based on the edition of SNT-TC-1A or CP-189 referenced in A-360.

PG-27 CYLINDRICAL COMPONENTS UNDER INTERNAL PRESSURE

PG-27.1 General. The formulas under this paragraph shall be used to determine the minimum required thickness or the maximum allowable working pressure of piping, tubes, drums, and headers in accordance with the appropriate dimensional categories as given in PG-27.2.1, PG-27.2.2, and PG-27.2.3 for temperatures not exceeding those given for the various materials listed in Tables 1A and 1B of Section II, Part D.

The calculated and ordered thickness of material must include the requirements of PG-16.2, PG-16.3, and PG-16.4. Stress calculations must include the loadings as defined in PG-22 unless the formula is noted otherwise.

When required by the provisions of this Code, allowance must be provided in material thickness for threading and minimum structural stability. (See PWT-9.2 and PG-27.4, Notes 3 and 5.)

PG-27.2 Formulas for Calculation

PG-27.2.1 Tubing — Up to and Including 5 in. (127 mm) Outside Diameter

$$t = \frac{PD}{2S + P} + 0.005D + e$$

$$P = S \left[\frac{2t - 0.01D - 2e}{D - (t - 0.005D - e)} \right]$$

See PG-27.4, Notes 2, 4, 8, and 10.

¹⁰ SNT-TC-1A and CP-189 are published by the American Society for Nondestructive Testing, 1711 Arlinggate Lane, PO Box 28518, Columbus, OH 43228-0518.

PG-27.2.1.1 For tubes of the materials listed in its title, Table PWT-10 may be used in lieu of the formula for determining the minimum wall thickness of tubes where expanded into drums or headers, provided the maximum mean wall temperature does not exceed 700°F (371°C).

PG-27.2.1.2 The wall thickness of the ends of tubes strength-welded to headers or drums need not be made greater than the run of the tube as determined by this formula.

PG-27.2.1.3 The wall thickness of the ends of tubes permitted to be attached by threading under the limitations of PWT-9.2 shall be not less than t as determined by this formula, plus $0.8/n$, where n equals the number of threads per inch.

PG-27.2.1.4 A tube in which a fusible plug is to be installed shall be not less than 0.22 in. (5.6 mm) in thickness at the plug in order to secure four full threads for the plug (see also A-20).

PG-27.2.1.5 Bimetallic tubes meeting the requirements of PG-9.4 shall use as an outside diameter D in the equation in PG-27.2.1 no less than the calculated outside diameter of the core material. The outside diameter of the core material shall be determined by subtracting the minimum thickness of the cladding from the outside diameter of the bimetallic tube, including the maximum plus tolerance. The minimum required thickness t shall apply only to the core material.

PG-27.2.2 Piping, Drums, and Headers. (Based on strength of weakest course)

$$t = \frac{PD}{2SE + 2yP} + C \quad \text{or} \quad \frac{PR}{SE - (1 - y)P} + C$$

$$P = \frac{2SE(t - C)}{D - 2y(t - C)} \quad \text{or} \quad \frac{SE(t - C)}{R + (1 - y)(t - C)}$$

See PG-27.4, Notes 1, 3, and 5 through 9.

PG-27.2.3 Thickness Greater Than One-Half the Inside Radius of the Component. The maximum allowable working pressure for parts of boilers of cylindrical cross section, designed for temperatures up to that of saturated steam at critical pressure [705.4°F (374.1°C)], shall be determined by the formulas in A-125.

PG-27.3 Symbols. Symbols used in the preceding formulas are defined as follows:



- t = minimum required thickness, in. (mm) (see PG-27.4, Note 7)
 P = maximum allowable working pressure, psi (kPa) (see PG-21)
 D = outside diameter of cylinder, in. (mm)
 R = inside radius of cylinder, in. (mm)
 E = efficiency (see PG-27.4, Note 1)
 S = maximum allowable stress value at the design temperature of the metal, as listed in the tables specified in PG-23, psi (see PG-27.4, Note 2)
 C = minimum allowance for threading and structural stability, in. (see PG-27.4, Note 3)
 e = thickness factor for expanded tube ends (see PG-27.4, Note 4)
 y = temperature coefficient (see PG-27.4, Note 6)

PG-27.4 Notes. Notes referenced in the preceding formulas are as follows:

Note 1:

- E = 1.00 for seamless or welded cylinders
 = the efficiency from PG-52 or PG-53 for ligaments between openings

01 Note 2:

The temperature of the metal to be used in selecting the S value for tubes shall not be less than the maximum expected mean wall temperature, i.e., the sum of the outside and inside tube surface temperatures divided by 2. For tubes that do not absorb heat, the metal temperature may be taken as the temperature of the fluid within the tube but not less than the saturation temperature.

Note 3:

Any additive thickness represented by the general term C may be considered to be applied on the outside, the inside, or both. It is the responsibility of the designer using these formulas to make the appropriate selection of diameter or radius to correspond to the intended location and magnitude of this added thickness. The pressure- or stress-related terms in the formula should be evaluated using the diameter (or radius) and the remaining thickness which would exist if the “additive” thickness had not been applied or is imagined to have been entirely removed.

The values of C below do not include any allowance for corrosion and/or erosion, and additional thickness should be provided where they are expected. Likewise, this allowance for threading and minimum structural stability is not intended to provide for conditions of misapplied external loads or for mechanical abuse.

Type of Pipe	Value of C^b , in. (mm)
Threaded steel, or nonferrous pipe ^a	
3/4 in. (19 mm) nominal, and smaller	0.065 (1.65)
1 in. (25 mm) nominal and larger	Depth of thread h^c
Plain end ^d steel, or nonferrous pipe	
3 1/2 in. (89 mm), nominal and smaller	0.065 (1.65)
4 in. (102 mm), nominal and larger	0

(a) Steel or nonferrous pipe lighter than Schedule 40 of ASME B36.10M, Welded and Seamless Wrought Steel Pipe, shall not be threaded.

(b) The values of C stipulated above are such that the actual stress due to internal pressure in the wall of the pipe is no greater than the values of S given in Table 1A of Section II, Part D, as applicable in the formulas.

(c) The depth of thread h in in. may be determined from the formula $h = 0.8/n$, where n is the number of threads per inch or from the following:

n	h
8	0.100
11 1/2	0.0696

(d) Plain-end pipe includes pipe jointed by flared compression couplings, lap (Van Stone) joints, and by welding, i.e., by any method that does not reduce the wall thickness of pipe at the joint.

Note 4:

- e = 0.04 over a length at least equal to the length of the seat plus 1 in. (25 mm) for tubes expanded into tube seats, except
 = 0 for tubes expanded into tube seats provided the thickness of the tube ends over a length of the seat plus 1 in. is not less than the following:
 0.095 in. (2.41 mm) for tubes 1 1/4 in. (32 mm) O.D. and smaller
 0.105 in. (2.67 mm) for tubes above 1 1/4 in. (32 mm) O.D. and up to 2 in. (51 mm) O.D., incl.
 0.120 in. (3.05 mm) for tubes above 2 in. (51 mm) O.D. and up to 3 in. (76 mm) O.D., incl.
 0.135 in. (3.43 mm) for tubes above 3 in. (76 mm) O.D. and up to 4 in. (102 mm) O.D., incl.
 0.150 in. (3.81 mm) for tubes above 4 in. (102 mm) O.D. and up to 5 in. (127 mm) O.D., incl.
 = 0 for tubes strength-welded to headers and drums

Note 5:

While the thickness given by the formula is theoretically ample to take care of both bursting pressure and material removed in threading, when steel pipe is threaded and used for steam pressures of 250 psi (1 720 kPa) and over, it shall be seamless and of a weight at least equal to Schedule 80 in order to furnish added mechanical strength.

01 Note 6:

y = a coefficient having values as follows:

	Temperature, °F (°C)							
	900 (482) and below	950 (510)	1,000 (538)	1,050 (566)	1,100 (593)	1,150 (621)	1,200 (649)	1,250 (677) and above
Ferritic	0.4	0.5	0.7	0.7	0.7	0.7	0.7	0.7
Austenitic	0.4	0.4	0.4	0.4	0.5	0.7	0.7	0.7
Alloy 800	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7
800H, 800HT	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7
825	0.4	0.4	0.4	...	...	...	...	...
230 Alloy	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7
NO6045	0.4	0.4	0.4	0.4	0.5	0.7	0.7	0.7

Values of y between temperatures listed may be determined by interpolation. For nonferrous materials, $y = 0.4$.

Note 7:

If pipe is ordered by its nominal wall thickness, as is customary in trade practice, the manufacturing tolerance on wall thickness must be taken into account. After the minimum pipe wall thickness t is determined by the formula, this minimum thickness shall be increased by an amount sufficient to provide the manufacturing tolerance allowed in the applicable pipe specification. The next heavier commercial wall thickness may then be selected from Standard thickness schedules as contained in ASME B36.10M. The manufacturing tolerances are given in the several pipe specifications listed in PG-9.

Note 8:

When computing the allowable pressure for a pipe of a definite minimum wall thickness, the value obtained by the formulas may be rounded out to the next higher unit of 10.

Note 9:

Inside backing strips, when used at longitudinal welded joints, shall be removed and the weld surface prepared for radiographic examination as required. Inside backing rings may remain at circumferential welded seams of cylinders provided such construction complies with requirements of PW-41.

Note 10:

The maximum allowable working pressure P need not include the hydrostatic head loading, PG-22, when used in this formula.

PG-28 WELDED ACCESS OR INSPECTION OPENINGS UNDER EXTERNAL PRESSURE

The maximum allowable working pressure for welded access or inspection openings, with inward projections subjected to external pressure (such as manhole or handhole rings with internal covers), may be determined

in accordance with the rules of PG-27 when the following requirements are met. The length of the internal projection of the ring extending past the toe of the attachment weld on the ring, shall not exceed the thickness of the ring. The length past the toe of the weld is measured at the location of the shortest ring projection into the vessel (see Fig. PG-28). For elliptical rings the value of D to be used in the procedures of PG-27 shall be determined in accordance with the following equation for elliptical rings:

$$D = a^2/b$$

where

a = outside major axis of the ellipse

b = outside minor axis of the ellipse

This provision does not apply to flanged in manholes covered by PG-29.3, PG-29.7, and PG-29.12.

PG-29 DISHED HEADS

PG-29.1 The thickness of a blank unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, shall be calculated by the following formula:

$$t = 5PL/4.8S$$

where

t = minimum thickness of head, in. (mm)

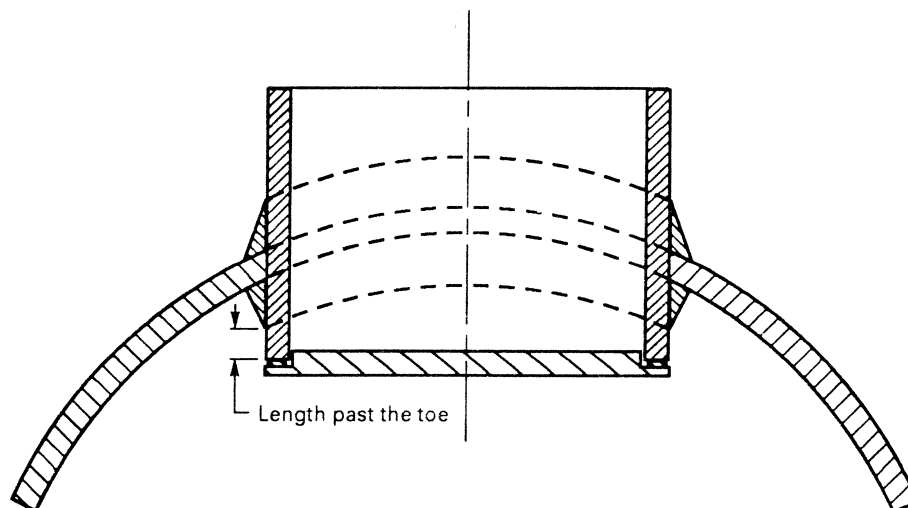
P = maximum allowable working pressure, psi (kPa) (hydrostatic head loading need not be included)

L = radius to which the head is dished, measured on the concave side of the head, in. (mm)

S = maximum allowable working stress, psi (kPa), using values given in Table 1A of Section II, Part D.

PG-29.2 The radius to which a head is dished shall be not greater than the outside diameter of flanged portion of the head. Where two radii are used the longer shall be taken as the value of L in the formula.

PG-29.3 When a head dished to a segment of a sphere has a flanged-in manhole or access opening that exceeds 6 in. (152 mm) in any dimension, the thickness shall be increased by not less than 15% of the required thickness for a blank head computed by the above formula, but in no case less than $\frac{1}{8}$ in. (3.2 mm) additional thickness over a blank head. Where such a dished head has a flanged opening supported by an attached flue, an increase in thickness over that for a



GENERAL NOTE: For other acceptable weld configurations, see Fig. PW-16.1.

FIG. PG-28 MAXIMUM INTERNAL PROJECTION OF WELDED ACCESS OR INSPECTION OPENINGS

blank head is not required. If more than one manhole is inserted in a head, the thickness of which is calculated by this rule, the minimum distance between the openings shall be not less than one-fourth of the outside diameter of the head.

PG-29.4 Except as otherwise provided for in PG-29.3, PG-29.7, and PG-29.12, all openings which require reinforcement, placed in a head dished to a segment of a sphere, or in an ellipsoidal head, or in a full-hemispherical head, including all types of manholes except those of the integral flanged-in type, shall be reinforced in accordance with the rules in PG-33.

When so reinforced, the thickness of such a head may be the same as for a blank unstayed head.

PG-29.5 Where the radius L to which the head is dished is less than 80% of the diameter of the shell, the thickness of a head with a flanged-in manhole opening shall be at least that found by making L equal to 80% of the diameter of the shell and with the added thickness for the manhole. This thickness shall be the minimum thickness of a head with a flanged-in manhole opening for any form of head and the maximum allowable working stress shall not exceed the values given in Table 1A of Section II, Part D.

PG-29.6 No head, except a full-hemispherical head, shall be of a lesser thickness than that required for a seamless shell of the same diameter.

PG-29.7 A blank head of a semiellipsoidal form in which half the minor axis or the depth of the head is at least equal to one-quarter of the inside diameter of the head shall be made at least as thick as the required thickness of a seamless shell of the same diameter as provided in PG-27.2.2. If a flanged-in manhole that meets the Code requirements is placed in an ellipsoidal head, the thickness of the head shall be the same as for a head dished to a segment of a sphere (see PG-29.1 and PG-29.5) with a dish radius equal to eight-tenths the diameter of the shell and with the added thickness for the manhole as specified in PG-29.3.

PG-29.8 When heads are made to an approximate ellipsoidal shape, the inner surface of such heads must lie outside and not inside of a true ellipse drawn with the major axis equal to the inside diameter of the head and one-half the minor axis equal to the depth of the head. The maximum variation from this true ellipse shall not exceed 0.0125 times the inside diameter of the head.

PG-29.9 Unstayed dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60% of that for heads of the same dimensions with the pressure on the concave side.

Head thicknesses obtained by using the formulas in PG-29.11 for hemispherical heads and PG-29.7 for

blank semiellipsoidal heads do not apply to heads with pressure on the convex side.

PG-29.10 When a flange of an unstayed dished head is machined to make a close and accurate fit into or onto the shell, the thickness shall not be reduced to less than 90% of that required for a blank head.

PG-29.11 The thickness of a blank unstayed full-hemispherical head with the pressure on the concave side shall be calculated by the following formulas:

$$t = \frac{PL}{1.6S} \quad (1)$$

$$t = \frac{PL}{2S - 0.2P} \quad (2)$$

where

t = minimum thickness of head, in. (mm)

P = maximum allowable working pressure, psi (kPa)

L = radius to which the head was formed, measured on the concave side of the head, in. (mm)

S = maximum allowable working stress, psi (kPa), using values given in Table 1A of Section II, Part D

Use Formula 1; however, Formula 2 may be used for heads exceeding $\frac{1}{2}$ in. (13 mm) in thickness that are to be used with shells or headers designed under the provisions of PG-27.2.2 and that are integrally formed on seamless drums or are attached by fusion welding, and do not require staying. Where Formula 2 is used, the other requirements of both of these paragraphs shall also apply.

The above formulas shall not be used when the required thickness of the head given by these formulas exceeds 35.6% of the inside radius, and instead, the following formula shall be used:

$$t = L(Y^{1/3} - 1)$$

where

$$Y = \frac{2(S + P)}{2S - P}$$

Joints in full-hemispherical heads including the joint to the shell shall be governed by and meet all the requirements for longitudinal joints in cylindrical shells, except that in a butt welded joint attaching a head to

a shell the middle lines of the plate thicknesses need not be in alignment.

PG-29.12 If a flanged-in manhole that meets the Code requirements is placed in a full-hemispherical head, the thickness of the head shall be the same as for a head dished to a segment of a sphere (see PG-29.1 and PG-29.5), with a dish radius equal to eight-tenths the diameter of the shell and with the added thickness for the manhole as specified in PG-29.3.

PG-29.13 The corner radius of an unstayed dished head measured on the concave side of the head shall be not less than three times the thickness of the material in the head; but in no case less than 6% of the diameter of the shell. In no case shall the thinning-down due to the process of forming, of the knuckle portion of any dished head consisting of a segment of a sphere encircled by a part of a torus constituting the knuckle portion (torispherical), exceed 10% of the thickness required by the formula in PG-29.1. Other types of heads shall have a thickness after forming of not less than that required by the applicable formula.

PG-30 STAYED DISHED HEADS

PG-30.1 When dished heads are of a thickness less than called for by PG-29, they shall be stayed as flat surfaces, no allowance being made in such staying for the holding power due to the spherical form unless all of the following conditions are met:

PG-30.1.1 That they be at least two-thirds as thick as called for by the rules for unstayed dished heads.

PG-30.1.2 That they be at least $\frac{7}{8}$ in. (22 mm) in thickness.

PG-30.1.3 That through-stays be used attached to the dished head by outside and inside nuts.

PG-30.1.4 That the maximum allowable working pressure shall not exceed that calculated by the rules for an unstayed dished head plus the pressure corresponding to the strength of the stays or braces secured by the formula for braced or stayed surfaces given in PG-46, using 1.3 for the value of C .

PG-30.2 If a dished head concave to pressure is formed with a flattened spot or surface, the diameter of the flat spot shall not exceed that allowable for flat heads as given by the formula in PG-31, using $C = 0.25$.

PG-31 UNSTAYED FLAT HEADS AND COVERS

PG-31.1 The minimum thickness of unstayed flat heads, cover plates, and blind flanges shall conform to the requirements given in this paragraph. These requirements apply to both circular and noncircular¹¹ heads and covers. Some acceptable types of flat heads and covers are shown in Fig. PG-31. In this figure, the dimensions of the welds are exclusive of extra metal required for corrosion allowance.

PG-31.2 The notations used in this paragraph and in Fig. PG-31 are defined as follows:

C = a factor depending on the method of attachment of head and on the shell, pipe, or header dimensions, and other items as listed in PG-31.4 below, dimensionless. The factors for welded covers also include a factor of 0.667 that effectively increases the allowable stress for such constructions to 1.5S.

D = long span of noncircular heads or covers measured perpendicular to short span, in. (mm)

d = diameter, or short span, measured as indicated in Fig. PG-31, in. (mm)

h_g = gasket moment arm, equal to the radial distance from the center line of the bolts to the line of the gasket reaction, as shown in Fig. PG-31, sketches (j) and (k), in. (mm)

L = perimeter of noncircular bolted head measured along the centers of the bolt holes, in. (mm)

l = length of flange of flanged heads, measured from the tangent line of knuckle, as indicated in Fig. PG-31, sketches (a) and (c), in. (mm)

m = the ratio t_r/t_s , dimensionless

P = maximum allowable working pressure, psi (kPa)

r = inside corner radius on a head formed by flanging or forging, in. (mm)

S = maximum allowable stress value, psi (kPa), using values given in Table 1A of Section II, Part D

t = minimum required thickness of flat head or cover, in. (mm)

t_e = minimum distance from beveled end of drum, pipe, or headers, before welding, to outer face of head, as indicated in Fig. PG-31, sketch (i), in. (mm)

t_f = actual thickness of the flange on a forged head,

at the large end, as indicated in Fig. PG-31, sketch (b), in. (mm)

t_h = actual thickness of flat head or cover, in. (mm)

t_r = thickness required for pressure of seamless shell, pipe, or header, in. (mm)

t_s = actual thickness of shell, pipe, or header, in. (mm)

t_w = thickness through the weld joining the edge of a head to the inside of a drum, pipe, or header, as indicated in Fig. PG-31, sketch (g), in. (mm)

t_l = throat dimension of the closure weld, as indicated in Fig. PG-31, sketch (r), in. (mm)

W = total bolt load, lb (kN), as further defined in PG-31.3.2

Z = a factor for noncircular heads and covers that depends on the ratio of short span to long span, as given in PG-31.3, dimensionless

PG-31.3 The thickness of flat unstayed heads, covers, and blind flanges shall conform to one of the following three requirements.¹²

PG-31.3.1 Circular blind flanges of ferrous materials conforming to ANSI B16.5-1981 shall be acceptable for the diameters and pressure-temperature ratings in Table 2 of that Standard when of the types shown in Fig. PG-31, sketches (j) and (k).

PG-31.3.2 The minimum required thickness of flat unstayed circular heads, covers, and blind flanges shall be calculated by the following equation:

$$t = d \sqrt{CP/S} \quad (1)$$

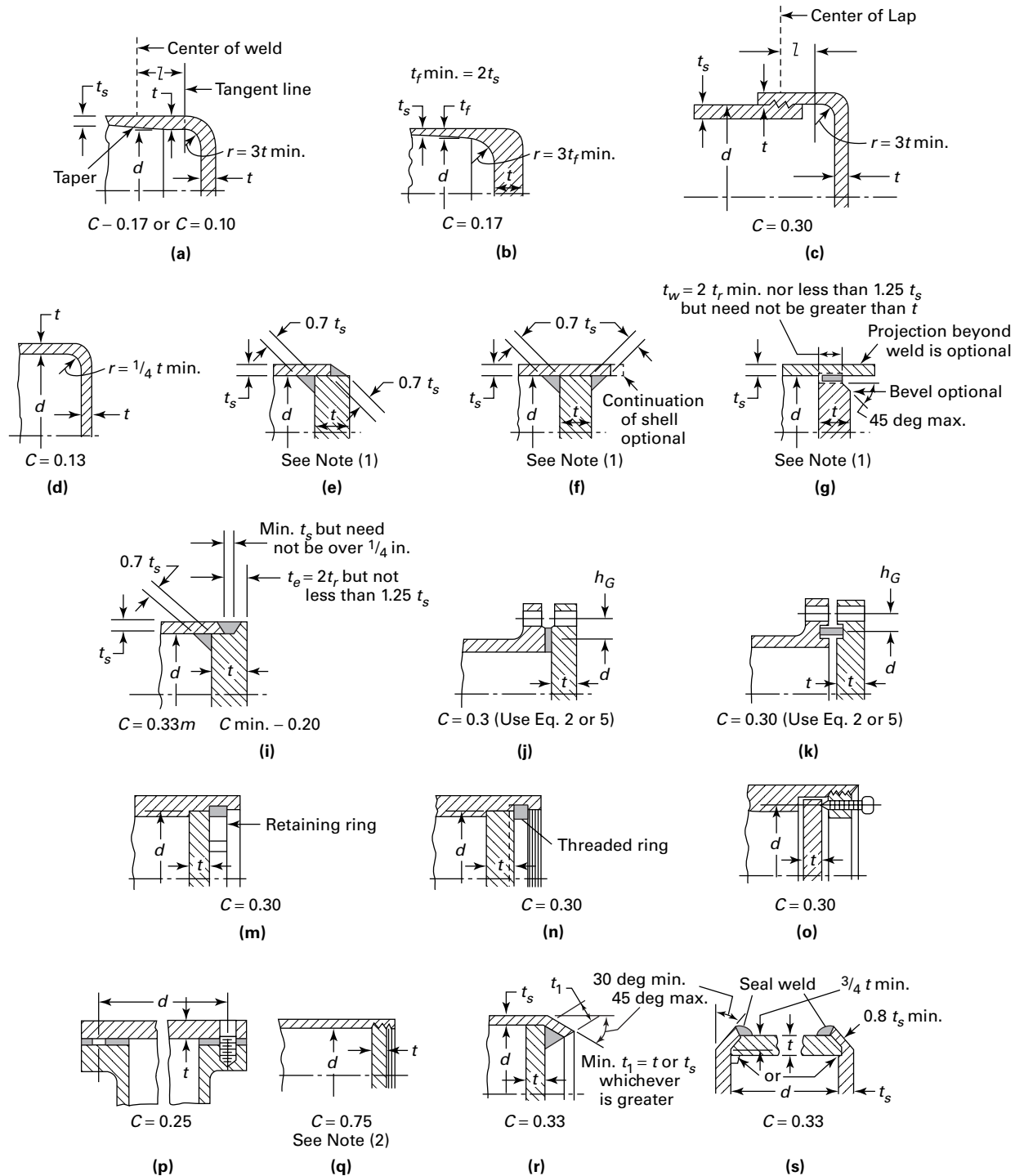
except when the head, cover, or blind flange is attached by bolts causing an edge moment [Fig. PG-31, sketches (j) and (k)] in which case the thickness shall be calculated by the following equation:

$$t = d \sqrt{CP/S + 1.9Wh_g/Sd^3} \quad (2)$$

When using Formula (2) the thickness t shall be calculated for both design conditions and gasket seating, and the greater of the two values shall be used. For design conditions, the value of P shall be the maximum allowable working pressure, the value of S at design temperature shall be used, and W shall be the sum of the bolt loads required to resist the end pressure load and to maintain tightness of the gasket. For gasket seating, P equals zero, the value of S at atmospheric

¹¹ Special consideration shall be given to the design of shells, nozzle necks, or flanges to which noncircular heads or covers are attached (see Preamble, second paragraph).

¹² The formulas provide safe construction as far as stress is concerned. Greater thicknesses may be necessary if deflection would cause leakage at threaded or gasketed joints.



GENERAL NOTE: The above illustrations are diagrammatic only. Other designs that meet the requires of PG-31 will be acceptable.

NOTES:

- (1) Sketches (e), (f), and (g) Circular Covers, $c = 0.33 m$, $c \text{ min.} = 0.20$; Noncircular Covers, $c = 0.33$.
 (2) When pipe threads are used, see Table PG-39.

FIG. PG-31 SOME ACCEPTABLE TYPES OF UNSTAYED FLAT HEADS AND COVERS

temperature shall be used, and W shall be the average of the required bolt load and the load available from the bolt area actually used.

PG-31.3.3 Flat unstayed heads, covers, or blind flanges may be square, rectangular, elliptical, obround, segmental, or otherwise noncircular. Their required thickness shall be calculated by the following formula:

$$t = d \sqrt{ZCP/S} \quad (3)$$

where

$$Z = 3.4 - \frac{2.4d}{D} \quad (4)$$

with the limitation that Z need not be greater than $2\frac{1}{2}$.

Formula (3) does not apply to noncircular heads, covers, or blind flanges attached by bolts causing a bolt edge moment [Fig. PG-31, sketches (j) and (k)]. For noncircular heads of this type, the required thickness shall be calculated by the following formula:

$$t = d \sqrt{ZCP/S + 6Wh_g/SLd^2} \quad (5)$$

When using Formula (5), the thickness t shall be calculated in the same way as specified above for Formula (2).

PG-31.4 For the types of construction shown in Fig. PG-31, the minimum values of C to be used in Formulas (1), (2), (3) and (5) are:¹³

Fig. PG-31, sketch (a): $C = 0.17$ for flanged circular and noncircular heads forged integral with or butt welded to the shell, pipe, or header, with an inside corner radius not less than three times the required head thickness, with no special requirement with regard to length of flange, and where the welding meets all the requirements for circumferential joints given in Part PW.

$C = 0.10$ for circular heads, where the flange length for heads of the above design is not less than

$$l = \left(1.1 - 0.8 \frac{t_s^2}{t_h^2}\right) \sqrt{dt_h} \quad (6)$$

When $C = 0.10$ is used, the slope of the tapered sections shall be no greater than 1:3.

Fig. PG-31, sketch (b): $C = 0.17$ for circular and noncircular heads forged integral with or butt welded to the shell, pipe, or header, where the corner radius on the inside is not less than three times the thickness

of the flange and where the welding meets all the requirements for circumferential joints given in Part PW.

Fig. PG-31, sketch (c): $C = 0.30$ for circular flanged plates screwed over the end of the shell, pipe, or header, with inside corner radius not less than $3t$, in which the design of the threaded joint against failure by shear, tension, or compression, resulting from the end force due to pressure, is based on a factor of safety of at least 4, and the threaded parts are at least as strong as the threads for standard piping of the same diameter. Seal welding may be used, if desired.

Fig. PG-31, sketch (d): $C = 0.13$ for integral flat circular heads when the dimension d does not exceed 24 in., the ratio of thickness of the head to the dimension d is not less than 0.05 nor greater than 0.25, the head thickness t_h is not less than the shell thickness t_s , the inside corner radius is not less than $0.25t$, and the construction is obtained by special techniques of upsetting and spinning the end of the shell, pipe, or header, such as are employed in closing header ends.

Fig. PG-31, sketches (e), (f), and (g): $C = 0.33m$ but not less than 0.20 for circular plates welded to the inside of a drum, pipe, or header, and otherwise meeting the requirements for the respective types of welded boiler drums, including postweld heat treatment when required for the drum, but omitting radiographic examination. If a value of m less than 1 is used in calculating t , the shell thickness t_s shall be maintained along a distance inwardly from the inside face of the head equal to at least $2\sqrt{dt_s}$. The throat thickness of the fillet welds in sketches (e) and (f) shall be at least $0.7t_s$. The size of the weld t_w in sketch (g) shall be not less than two times the required thickness of a seamless shell nor less than 1.25 times the nominal shell thickness but need not be greater than the head thickness; the weld shall be deposited in a welding groove with the root of the weld at the inner face of the head as shown in the figure.

$C = 0.33$ for noncircular plates, welded to the inside of a drum, pipe, or header, and otherwise meeting the requirements for the respective types of welded boiler drums, including postweld heat treatment when required for the drum, but omitting radiographic examination. The throat thickness of the fillet welds in sketches (e) and (f) shall be at least $0.7t_s$. The size of the weld t_w in sketch (g) shall be not less than two times the required thickness of a seamless shell nor less than 1.25 times the nominal shell thickness but need not be greater than the head thickness; the weld shall be deposited in a welding groove with the root of the weld at the inner face of the head as shown in the figure.

¹³ Radiographic examination is not required for any of the weld joints shown in Fig. PG-31, sketches (e), (f), (g), (i), (r), and (s).

Fig. PG-31, sketch (i): $C = 0.33m$ but not less than 0.20 for circular plates welded to the end of the drum, pipe, or header, when an inside weld with minimum throat thickness of $0.7t_s$ is used, and when the beveled end of the drum, pipe, or header is located at a distance not less than $2t_r$ nor less than $1.25t_s$ from the outer face of the head. The width at the bottom of the welding groove shall be at least equal to t_s but need not be over $\frac{1}{4}$ in. (6 mm).

Fig. PG-31, sketches (j) and (k): $C = 0.3$ for circular and noncircular heads and covers bolted to the shell, flange, or side plate as indicated in the figures. Note that Eq. (2) or (5) shall be used because of the extra moment applied to the cover by the bolting. When the cover plate is grooved for a peripheral gasket, as shown in sketch (k) the net cover plate thickness under the groove or between the groove and the outer edge of the cover plate shall be not less than

$$d \sqrt{1.9 Wh_g / Sd^3}$$

for circular heads and covers, not less than

$$d \sqrt{6 Wh_g / SLd^2}$$

for noncircular heads and covers.

Fig. PG-31, sketches (m), (n), and (o): $C = 0.3$ for a circular plate inserted into the end of a shell, pipe, or header and held in place by a positive mechanical locking arrangement, and when all possible means of failure either by shear, tension, compression, or radial deformation, including flaring, resulting from pressure and differential thermal expansion, are resisted with a factor of safety of at least 4. Seal welding may be used, if desired.

Fig. PG-31, sketch (p): $C = 0.25$ for circular and noncircular covers bolted with a full-face gasket to shell, flanges, or side plates.

Fig. PG-31, sketch (q): $C = 0.75$ for circular plates screwed into the end of a shell, pipe, or header having an inside diameter d not exceeding 12 in. (305 mm); or for heads having an integral flange screwed over the end of a shell, pipe, or header having an inside diameter d not exceeding 12 in. (152 mm); and when the design of the threaded joint against failure by shear, tension, compression, or radial deformation, including flaring, resulting from pressure and differential thermal expansion, is based on a factor of safety of at least 4. If a tapered pipe thread is used, the requirements of Table PG-39 shall be met. Seal welding may be used, if desired.

Fig. PG-31, sketch (r): $C = 0.33$ for circular plates having a dimension d not exceeding 18 in. (457 mm) inserted into the shell, pipe, or header and welded as shown, and otherwise meeting the requirements for welded boiler drums including postweld heat treatment but omitting radiographic examination. The end of the shell, pipe, or header shall be crimped over at least 30 deg, but not more than 45 deg. The crimping may be done cold only when this operation will not injure the metal. The throat of the weld shall be not less than the thickness of the flat head or the shell, pipe, or header, whichever is greater.

Fig. PG-31, sketch (s): $C = 0.33$ for circular beveled plates having a diameter d not exceeding 18 in. (457 mm) inserted into a shell, pipe, or header, the end of which is crimped over at least 30 deg, but not more than 45 deg, and when the undercutting for seating leaves at least 80% of the shell thickness. The beveling shall be not less than 75% of the head thickness. The crimping shall be done when the entire circumference of the cylinder is uniformly heated to the proper forging temperature for the material used. For this construction, the ratio t_s/d shall be not less than the ratio P/S nor less than 0.05. The maximum allowable working pressure for this construction shall not exceed $P = 5S/d$.

OPENINGS AND COMPENSATION¹⁴

PG-32 OPENINGS IN SHELLS, HEADERS, AND HEADS

PG-32.1 Scope

PG-32.1.1 The rules for openings and compensation in PG-32 through PG-39 shall apply to all openings in shells, headers, and heads except as otherwise provided in PG-29.3, PG-29.7, PG-29.12, PG-32.1.2, PG-32.1.3.1, PG-32.1.4, and PG-32.1.5.

PG-32.1.2 Openings in a definite pattern, such as tube holes, may be designed in accordance with the rules for ligaments in PG-52, provided the diameter of the largest hole in the group does not exceed that permitted by the chart in Fig. PG-32.

The notation used in Fig. PG-32 is defined as follows:

¹⁴ The rules governing openings as given in this Code are based on the stress intensification created by the existence of a hole in an otherwise symmetrical section. They are based on experience with vessels designed with safety factors of 4 and 5 applied to the specified minimum tensile strength of the shell material. External loadings such as those due to thermal expansion or to unsupported weight of connecting piping have not been evaluated. These factors should be given attention in unusual designs or under conditions of cyclic loading.

P = maximum allowable working pressure, psi (kPa)
 d = maximum allowable diameter of openings, in. (mm)
 D = outer diameter of the shell, in. (mm)
 t = actual thickness of the shell, in. (mm)
 S = maximum allowable stress value, psi (kPa), taken from Tables 1A and 1B of Section II, Part D

$$K = \frac{PD}{1.82St}$$

PG-32.1.3.1 No calculation need be made to determine the availability of compensation for a single opening, not covered by PG-38 or PG-52, in shells, headers, or formed heads whose inside diameter is not less than four times the diameter of the opening and which satisfies the following conditions:

PG-32.1.3.1.1 Welded connections not larger than NPS 2 attached in accordance with the applicable rules.

PG-32.1.3.1.2 Threaded, studded, or expanded connections in which the diameter of the hole in the vessel wall is not greater than NPS 2.

PG-32.1.3.2 No calculations need be made to demonstrate compliance with PG-33 for single openings not covered in PG-32.1.3.1 when the diameter of the opening in the shell or header does not exceed that permitted in Fig. PG-32.

PG-32.1.4 No calculation need be made to determine the availability of compensation for a single opening in a formed head that satisfies the following conditions.

PG-32.1.4.1 The minimum center-to-center distance between adjacent openings shall not be less than L as determined by the following equation:

$$L = \frac{A + B}{2(1 - K)}$$

where

$$K = PD/1.82 St$$

L = the distance between centers of the two openings measured on the surface of the formed head, in. (mm)

A, B = the outside diameter of each opening respectively, in. (mm)

P = the maximum allowable working pressure, psig (kPa)
 D = the outside diameter of the formed head, in. (mm)
 t = the actual thickness of the head, in. (mm)
 S = the maximum allowable stress value of the head material, as taken from Tables 1A and 1B of Section II, Part D, psi (MPa)

PG-32.1.4.2 The edge of the opening shall come no closer to the line bounding the spherical or ellipsoidal portion of the formed head, or around a flanged-in manhole, than a distance equal to the thickness of the head, and in no case, except for water column connections, shall the opening come within the part formed by the corner radius of a dished head.

PG-32.1.4.3 The maximum allowable diameter of any opening in a formed head, except in a full-hemispherical head, shall not exceed that permitted in PG-32.1.3.1 for an equivalent shell. The equivalent shell shall be of the same material as the head; of the same outside diameter as the outside diameter of the flange of the head; and of the same maximum allowable working pressure as the head.

PG-32.1.4.4 The maximum allowable diameter of any opening in a full-hemispherical head shall comply with the requirements in PG-32.1.4.3 except that the value of K used in PG-32.1.4.1 and the chart in Fig. PG-32 shall be one-half the value given by the equation in PG-32.1.4.1.

PG-32.1.5 No calculation need be made to demonstrate compliance with PG-33 for single openings not covered in PG-32.1.4 when the diameter of the opening in the formed head does not exceed that permitted in Fig. PG-32.

PG-32.2 Shape of Openings¹⁵

PG-32.2.1 Openings in cylindrical portions of vessels or in formed heads shall preferably be circular, elliptical, or obround.¹⁶

When the long dimension of an elliptical or obround opening exceeds twice the short dimension, the compensation across the short dimension shall be increased as necessary to provide against excessive distortion due to twisting moment.

¹⁵ The opening made by a pipe or a circular nozzle, the axis of which is not perpendicular to the vessel wall or head, may be considered an elliptical opening for design purposes.

¹⁶ An obround opening is one which is formed by two parallel sides and semicircular ends.

PG-32.2.2 Openings may be of other shapes than those given in PG-32.2.1, and all corners shall be provided with a suitable radius. When the openings are of such proportions that their strength cannot be computed with assurance of accuracy, or when doubt exists as to the safety of a vessel with such openings, the part of the vessel affected shall be subjected to a proof hydrostatic test as prescribed in PG-100.

PG-32.3 Size of Openings

PG-32.3.1 Properly reinforced openings in cylindrical and spherical shells are not limited as to size and shall comply with the provisions that follow, and with the additional provisions given under PG-32.3.2.

PG-32.3.2 The rules given herein for compensation apply to openings not exceeding the following dimensions:

For vessels 60 in. (1 520 mm) in diameter and less: $\frac{1}{2}$ the vessel diameter but not over 20 in. (508 mm).

For vessels over 60 in. (1 520 mm) in diameter: $\frac{1}{3}$ the vessel diameter but not over 40 in. (1 000 mm).

PG-32.3.3 Larger openings should be given special attention and may be provided with compensation in any suitable manner that complies with the intent of the Code rules. It is recommended that the compensation provided be distributed close to the opening. (A provision of about two-thirds of the required compensation within a distance of one-fourth of the nozzle diameter on each side of the finished opening is suggested.) Special consideration should be given to the fabrication details used and the inspection employed on critical openings; compensation often may be advantageously obtained by use of a thicker shell plate for a vessel course or inserted locally around the opening; welds may be ground to concave contour and the inside corners of the opening rounded to a generous radius to reduce stress concentrations. Appropriate proof testing may be advisable in extreme cases of large openings approaching full vessel diameter, openings of unusual shape, etc.

PG-33 COMPENSATION REQUIRED FOR OPENINGS IN SHELLS AND FORMED HEADS

PG-33.1 General. The rules in this subparagraph apply to all openings other than flanged-in openings in formed heads covered by PG-29.3, PG-29.7, and PG-29.12; openings in flat heads covered by PG-35; and openings covered within PG-32.1.2, PG-32.1.3.1, PG-32.1.3.2, PG-32.1.4, and PG-32.1.5.

Compensation shall be provided in such amount and distribution that the requirements for area of compensation are satisfied for all planes through the center of the opening and normal to the vessel surface. For a circular opening in a cylindrical shell, the plane containing the axis of the shell is the plane of greatest loading due to pressure.

PG-33.2 Area Required. The total cross-sectional area of compensation, A , required in any given plane for a vessel under internal pressure shall be not less than

$$A = d \times t_r \times F$$

where

d = the diameter in the given plane of the finished opening, in. (mm) (see Figs. PG-36 and PW-16.1)

F = a correction factor that compensates for the variation in pressure stresses on different planes with respect to the axis of a vessel. A value of 1.00 shall be used for all configurations except that Fig. PG-33 may be used for integrally reinforced openings in cylindrical shells.

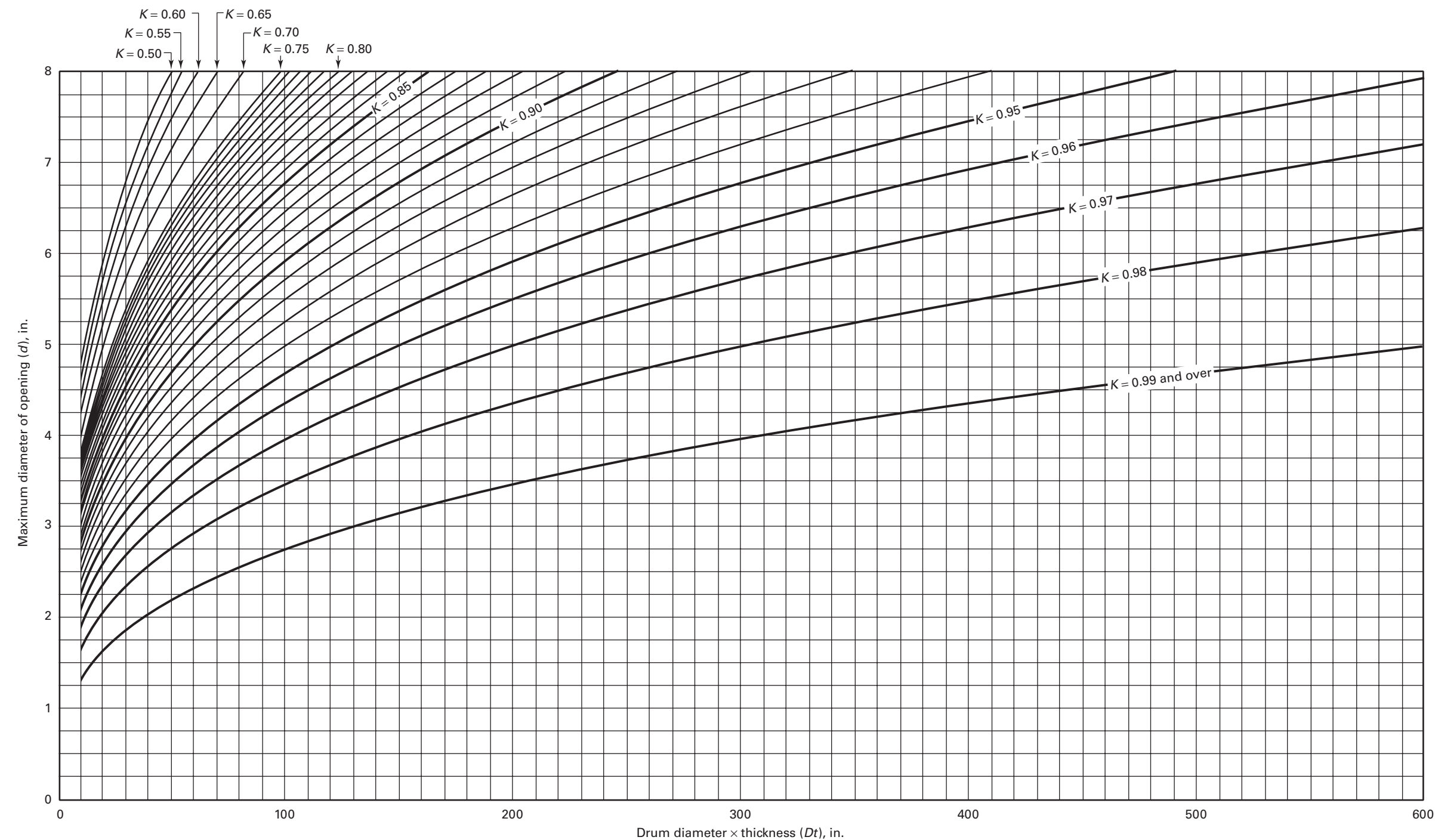
t_r = the required thickness of a seamless shell or head computed by the rules of the Code for the designated pressure, in. (mm), except that:

PG-33.2.1 When the opening and its compensation are in a torispherical head and are entirely within the spherical portion, t_r is the thickness required for a seamless hemispherical head of the same radius as that of the spherical portion.

PG-33.2.2 When the opening and its compensation are in an ellipsoidal head in which one-half of the minor axis is equal to one-fourth of the inside diameter, and are located entirely within a circle the center of which coincides with the center of the head and the diameter of which is equal to 80% of the shell inside diameter, t_r is the thickness required for a seamless hemispherical head of radius equal to 90% of the inside diameter of the shell.

PG-34 FLANGED-IN OPENINGS IN FORMED HEADS

PG-34.1 All openings in torispherical, ellipsoidal, and hemispherical heads shall be provided with reinforcement in accordance with PG-33, except for heads which meet the requirements in PG-34.2 and PG-29.3, PG-29.7, and PG-29.13.



GENERAL NOTES:
(a) The equation is provided for the user's option. Three significant figures shall be employed for the variables in the equation and in the resulting value of d . Additional significant figures are permitted but not required. Use of the equation beyond the range of the abscissa and ordinate shown in the diagram is prohibited. K as used in the equation is limited to 0.990.
(b) K -lines are shown only for 50% and higher. By the provisions of PG-33 an opening is fully compensated for K less than 0.5.
(c) $d = 2.75 [Dt (1 - K)]^{1/3}$

FIG. PG-32 CHART SHOWING LIMITS OF SIZES OF OPENINGS WITH INHERENT COMPENSATION IN CYLINDRICAL SHELLS
Maximum Permissible Diameter of Opening Is 8 in. (1 in. = 25.4 mm)





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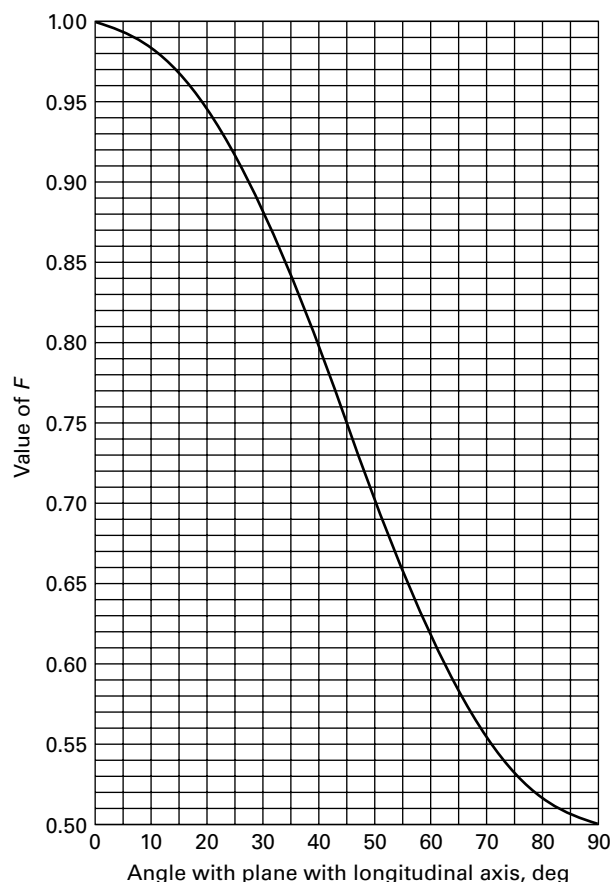


FIG. PG-33 CHART FOR DETERMINING
VALUE OF F

(Determine value of F as required in PG-33.2)

PG-34.2 A flanged-in manhole opening in a dished head shall be flanged to a depth of not less than three times the required thickness of the head for plate up to $1\frac{1}{2}$ in. (38 mm) in thickness. For plate exceeding $1\frac{1}{2}$ in. (38 mm) in thickness, the depth shall be the thickness of the plate plus 3 in. (76 mm). The depth of flange shall be determined by placing a straight edge across the outside opening along the major axis and measuring from the straight edge to the edge of the flanged opening. A manhole opening may be compensated by a manhole ring or other attachment in place of flanging in accordance with PG-33.

PG-35 COMPENSATION REQUIRED FOR OPENINGS IN FLAT HEADS

PG-35.1 General. The rules in this paragraph apply to all openings other than small openings covered by PG-32.1.3.1.

PG-35.2 Flat heads that have an opening with a diameter that does not exceed one-half of the head diameter or shortest span, as defined in PG-31, shall have a total cross-sectional area of compensation not less than that given by the formula:

$$A = 0.5d \times t$$

where

d = the diameter in the given plane of the finished opening (Fig. PG-36 and Fig. PW-16.1), in. (mm)

t = minimum required thickness of flat head, in. (mm)

As an alternative, the thickness may be increased to provide the necessary openings compensation as follows:

PG-35.2.1 By using $2C$ or 0.75 in place of C , whichever is less, in Formula (1) or (3) for calculating head thickness in PG-31.3; or

PG-35.2.2 In Formula (2) or (5) by doubling the quantity under the square root sign.

PG-35.3 Flat heads that have an opening with a diameter that exceeds one-half of the head diameter or shortest span, as defined in PG-31.3, shall be designed as a flange in accordance with accepted Rules for Bolted Flange Connections.

PG-36 LIMITS OF METAL AVAILABLE FOR COMPENSATION

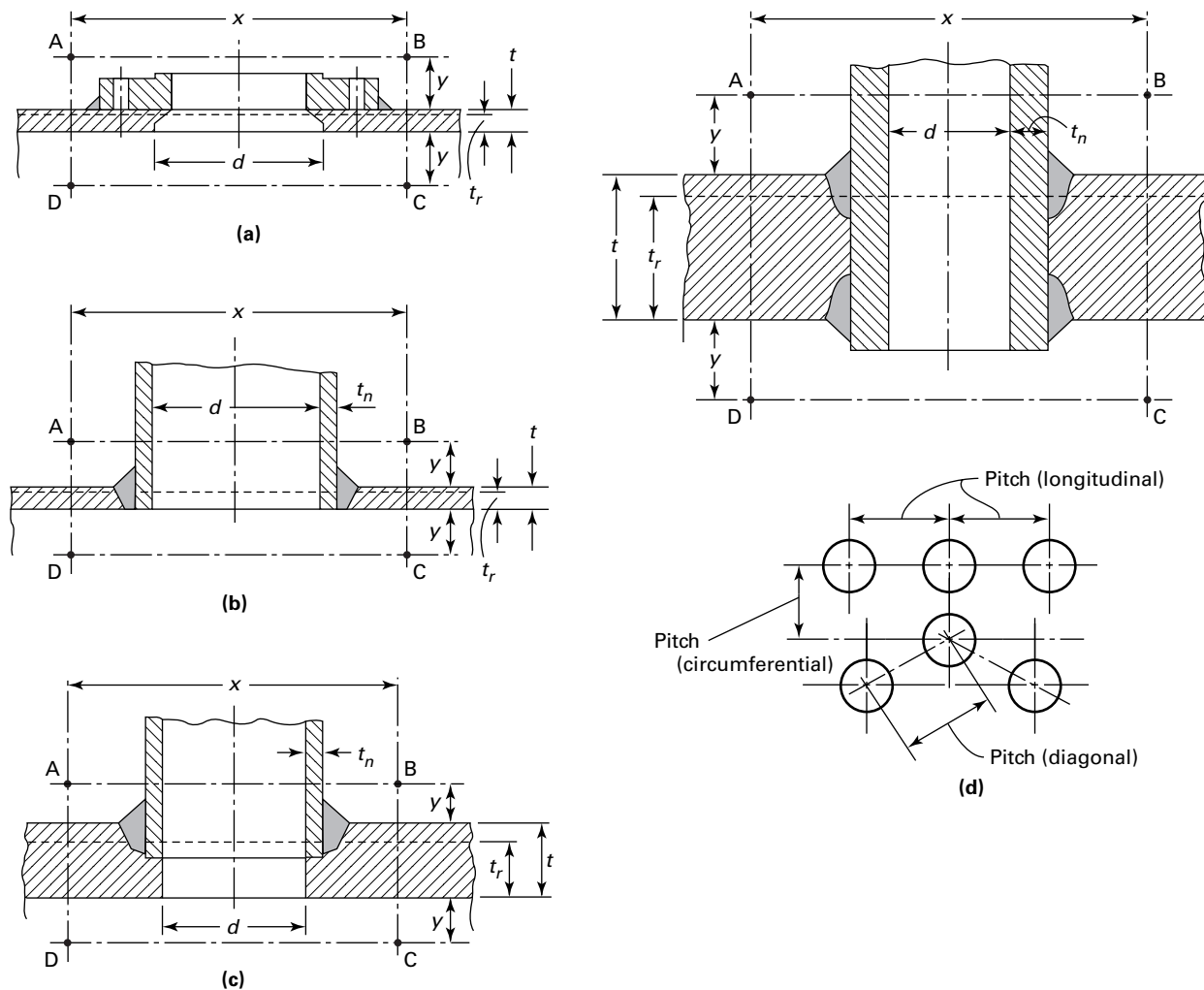
PG-36.1 The boundaries of the cross-sectional area in any plane normal to the vessel wall and passing through the center of the opening within which area metal must be located in order to have value as compensation are designated as the limits of compensation for that plane. (See Fig. PG-36.)

PG-36.2 The limits of compensation, measured parallel to the vessel wall, shall be at a distance, on each side of the axis of the opening, equal to the greater of the following:

PG-36.2.1 The diameter of the finished opening.

PG-36.2.2 The radius of the finished opening plus the thickness of the vessel wall, plus the thickness of the nozzle wall.

PG-36.3 The limits of compensation, measured normal to the vessel wall, shall conform to the contour



GENERAL NOTE: Rectangle ABCD represents limits of reinforcement:
 $x =$ the greater of $2d$ or $d + 2(t + t_n)$ but in no case greater than the pitch between openings
 $y =$ the smaller of $2\frac{1}{2}t$ or $2\frac{1}{2}t_n$

FIG. PG-36 LIMITS OF REINFORCEMENT FOR TYPICAL OPENINGS

of the surface at a distance from each surface equal to the smaller of the following:

PG-36.3.1 $2\frac{1}{2}$ times the nominal shell thickness.

PG-36.3.2 $2\frac{1}{2}$ times the nozzle-wall thickness plus the thickness of any added compensation, exclusive of weld metal on the side of the shell under consideration.

PG-36.4 Metal within the limits of reinforcement that may be considered to have reinforcing value shall include the following:

PG-36.4.1 Metal in the vessel wall over and above the thickness required to resist pressure. The area of the vessel wall available as compensation is the larger of the values of A_1 given by the formulas:

$$A_1 = (t - Ft_r)d$$

or

$$A_1 = 2(t - Ft_r)(t + t_n)$$

PG-36.4.2 Metal over and above the thickness required to resist pressure in that part of a nozzle wall extending outside the vessel wall. The maximum area in the nozzle wall available as compensation is the smaller of the values of A_2 given by the formulas:

$$A_2 = (t_n - t_{rn})5t$$

$$A_2 = (t_n - t_{rn})(5t_n + 2t_e)$$

All metal in the nozzle wall extending inside the vessel wall may be included. No allowance shall be taken for the fact that a differential pressure on an inwardly extending nozzle may cause opposing stress to that of the stress in the shell around the opening.

PG-36.4.3 Metal added as compensation (continuously about the nozzle) when welded to both the vessel and nozzle, and metal provided in attachment welds.

PG-36.4.4 The notation used in this paragraph is defined as follows:

A_1 = area in excess thickness in the vessel wall available for compensation, sq in. (mm²) (see PG-36.4.1)

A_2 = area in excess thickness in the nozzle wall available for compensation, sq in. (mm²) (see PG-36.4.2)

t_e = thickness of attached reinforcing pad or height of the largest 60 deg right triangle supported by the vessel and nozzle outside diameter projected surfaces and lying completely within the area

of integral reinforcement, in. (mm) (see Fig. PG-36.4)

t = thickness of the vessel wall, in. (mm)

t_r = required thickness of a seamless shell or head as defined in PG-33, in. (mm)

t_n = nominal thickness of nozzle wall, in. (mm)

t_{rn} = required thickness of seamless nozzle wall, in. (mm); found by the formula used for t_r for the shell, omitting the C factor (the value of S used in determining t_{rn} shall be based on the nozzle material). The value of t_{rn} shall be taken as zero for the entire wall of manhole and handhole rings projecting internally with the cover on the inside.

d = diameter in the plane under consideration of the finished opening, in. (mm) (see Fig. PG-36, Fig. PG-36.4, and Fig. PW-16.1)

d = the maximum diameter of the threads, in the plane under consideration, in the finished opening, for inside tapped NPT fittings, in. (mm)

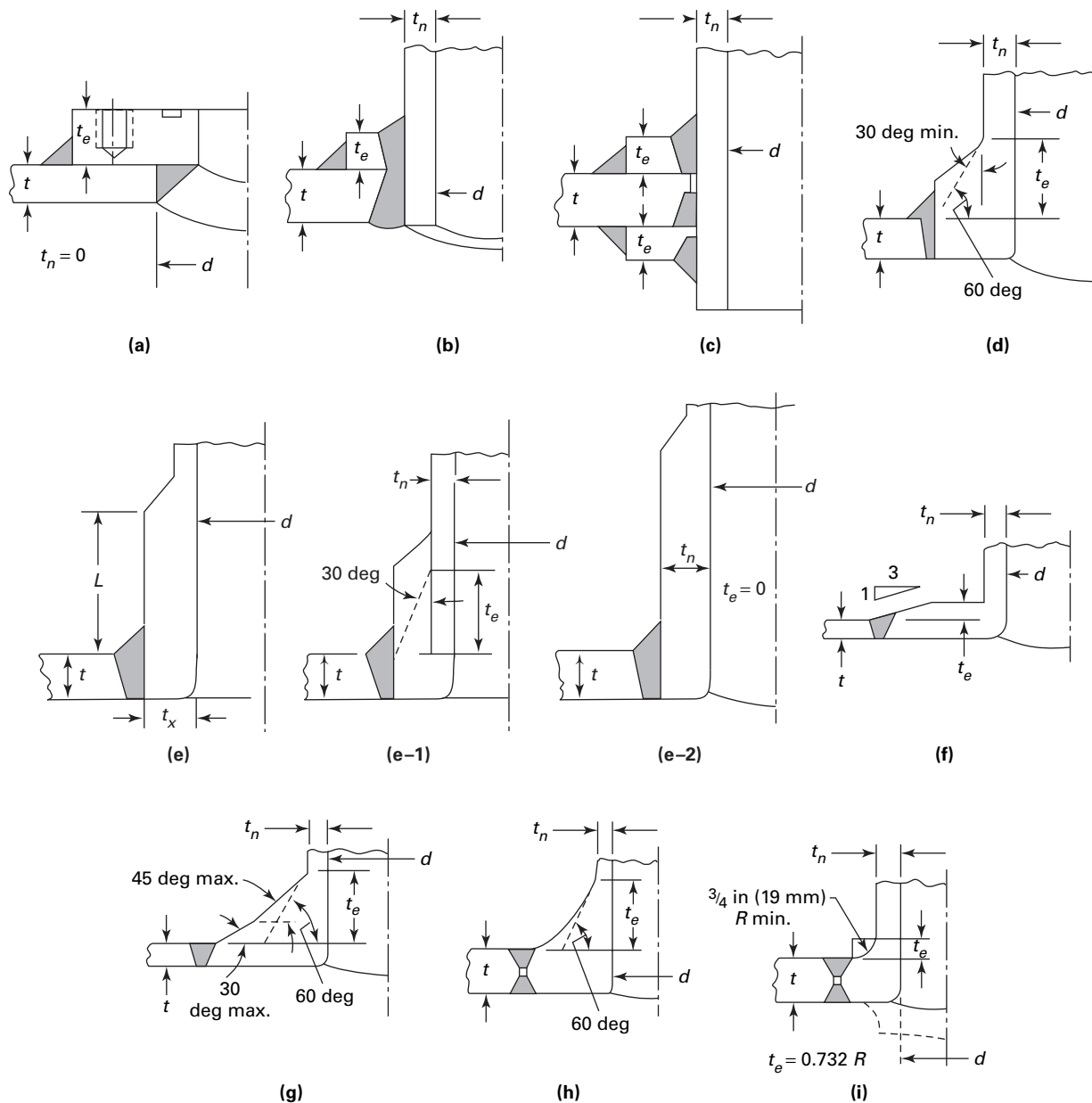
F = factor from PG-33 and Fig. PG-33

PG-36.5 Typical examples of the application of the above rules are presented in A-65 through A-69.

PG-37 STRENGTH OF COMPENSATION

PG-37.1 Material used for compensation shall have an allowable stress value equal to or greater than that of the material in the vessel wall, except that material of lower strength may be used provided the area of compensation is increased in inverse proportion to the ratio of the allowable stress values of the two materials to compensate for the lower allowable stress value of the compensation. No credit may be taken for the additional strength of any compensation having a higher allowable stress value than that of the vessel wall. Deposited weld metal outside of either the vessel wall or any reinforcing pad used as reinforcement shall be credited with an allowable stress value equivalent to the weaker of the materials connected by the weld. Vessel-to-nozzle or pad-to-nozzle attachment weld metal within the vessel wall or within the pad may be credited with a stress value equal to that of the vessel wall or pad, respectively.

PG-37.2 The minimum required strength of each load-carrying path, as defined in PW-15 and Fig. PW-16, through the welded nozzle attachment shall be at least equal to the smallest of the values of W as determined by the following equations:



GENERAL NOTE: Use sketch (e) to determine whether sketch (e-1) or (e-2) applies:

- (a) If $L < 2.5 t_x$, use sketch (e-1).
- (b) If $L \geq 2.5 t_x$, use sketch (e-2).

$$W = dt_r S \quad (1)$$

$$W = (dlt_r - [(2d - dl)(t - t_r)] + A_s)S \quad (2)$$

$$W = (dlt_r - [2t(t - t_r)] + A_s)S \quad (3)$$

PG-37.2.1 The notations used in PG-37.2 are defined as follows:

A_s = two times the stud hole depth by the stud hole width when the stud holes are tapped directly into the vessel wall, sq in. (mm²)

d = see definition in PG-36.4.4

dl = the diameter of the unfinished opening in the plane of consideration prior to the nozzle installation, in. (mm)

t = see definition in PG-36.4.4

t_n = see definition in PG-36.4.4

t_r = see definition in PG-36.4.4

S = the maximum allowable stress value of the vessel material, as taken from Tables 1A and 1B of Section II, Part D, psi (kPa)

W = the required minimum strength to be provided by the combined strength of the load-carrying elements through each load-carrying path, lb (kN) (If W is determined to be negative in value, then W should be considered as zero.)

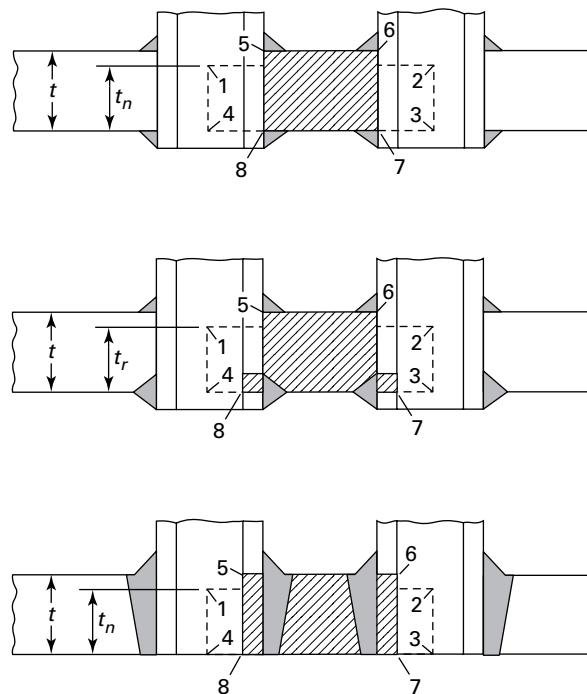
PG-37.3 The strength of the attachment joint shall be considered for its entire length on each side of the plane defined in PG-36.

PG-37.4 Manhole frames on shells or drums shall have the proper curvature and shall be attached by welding provided the requirements of Part PW, omitting the radiographic examination, and PG-32 are met.

PG-37.5 For detailed requirements for compensation attached by welding, see the appropriate paragraphs in PW-15.

PG-38 COMPENSATION FOR MULTIPLE OPENINGS

PG-38.1 When any two adjacent openings that require compensation are spaced at less than two times the distance defined in PG-36.2 and PG-36.3 so that their limits of compensation overlap, the two openings (or similarly for any larger group of openings) shall be compensated in accordance with PG-33 with a compensation that has an area equal to the combined area of the compensation required for the separate openings. No portion of the cross section shall be considered as



GENERAL NOTE: The cross-sectional area represented by 5, 6, 7, and 8 shall be at least equal to the area of the rectangle represented by 1, 2, 3, and 4 multiplied by 0.7F, in which F is a value from Fig. PG-33 and t_r is the required thickness of a seamless shell.

FIG. PG-38 ILLUSTRATIONS OF THE RULE GIVEN IN PG-38.4

applying to more than one opening, or be evaluated more than once in a combined area.

PG-38.2 Two adjacent openings shall have a distance between centers not less than $1\frac{1}{3}$ times their average diameter.

PG-38.3 When a group of openings is provided with compensation by a thicker section butt welded into the shell or head, the edges of the inserted section shall be tapered as prescribed in PW-9.3.

PG-38.4 When a shell or drum has a series of holes in a definite pattern, the net cross-sectional area between any two finished openings within the limits of the actual shell wall, excluding the portion of the compensation not fused to the shell wall, shall equal at least 0.7F of the cross-sectional area obtained by multiplying the center-to-center distance of the openings by the required thickness of a seamless shell, where the factor F is taken from Fig. PG-33 for the plane under consideration. (See Fig. PG-38.)

PG-39 METHODS OF ATTACHMENT OF PIPE AND NOZZLE NECKS TO VESSEL WALLS

PG-39.1 General. Except as limited in PG-32, nozzles may be attached to the shell or head of a vessel by any of the methods of attachment given in this paragraph.

PG-39.2 Welded Connections. Attachment by welding shall be in accordance with the requirements of PW-15 and PW-16.

PG-39.4 Studded Connections. Connections may be made by means of bolt studs. The vessel shall have a flat surface machined on the shell, or on a built-up pad, or on a properly attached plate or fitting. Drilled holes to be tapped for straight threads shall not penetrate within one-fourth of the wall thickness from the inside surface of the vessel, unless at least the minimum thickness required as above is maintained by adding metal to the inside surface of the vessel. Where tapped holes are provided for studs, the threads shall be full and clean and shall engage the stud for a length not less than the larger of d_s or

$$0.75d_s \times \frac{\text{Maximum allowable stress value of stud material at design temperature}}{\text{Maximum allowable stress value of tapped material at design temperature}}$$

in which d_s is the diameter of the stud, except that the thread engagement need not exceed $1\frac{1}{2}d_s$. Studded connections shall meet the requirements for compensation. No credit for compensation shall be allowed for any areas attached by studs only.

PG-39.5 Threaded Connections

PG-39.5.1 Where a threaded connection is to be made to a boiler component it shall be into a threaded hole. The threads shall conform to the requirements of ANSI B1.20.1 and provide for the pipe to engage the minimum number of threads specified in Table PG-39 after allowance has been made for curvature of the vessel wall. A built-up pad or properly attached plate or fitting may be used to provide the metal thickness and number of threads required in Table PG-39, or to furnish compensation when required.

PG-39.5.2 Threaded joints for boiler connections for external piping shall be in accordance with the following size and pressure limitations and shall not be used where the temperature exceeds 925°F.

Maximum Size, NPS (DN)	Maximum Pressure, psi (kPa)
3 (80)	400 (2 800)
2 (50)	600 (4 140)
1 (25)	1,200 (8 270)
$\frac{3}{4}$ (20) and smaller	1,500 (10 300)

PG-39.5.3 Threaded connections for plug closures used for inspection openings, end closures, and similar purposes may be used within the size and pressure limitations of Table PG-39.

PG-39.6 Expanded Connections. Provided the requirements for compensation are met, a pipe, tube, or forging not exceeding 6 in. (152 mm) in outside diameter may be attached to shells, heads, headers, or fittings by inserting through an opening and expanding in accordance with the rules for tube attachment in Parts PWT and PFT, whichever is applicable.

The sharp edges left in drilling tube holes shall be removed on both sides of the plate with a file or other tool. The inner surface of the tube hole in any form of attachment may be grooved or chamfered.

PG-39.7 All welded connections shall be postweld heat treated after attachment unless specifically allowed otherwise.

PG-42 GENERAL REQUIREMENTS FOR FITTINGS, FLANGES, AND VALVES

PG-42.1 Applicable ASME Standards. Except when supplied as miscellaneous pressure parts under the provisions of PG-11, all fittings, flanges, and valves shall meet the requirements of the following ASME Standards, including the restrictions contained within the standards, and any noted as part of this Code. The product standard establishes the basis for pressure-temperature rating and marking.

PG-42.1.1 ASME B16.1, Cast Iron Pipe Flanges and Flanged Fittings¹⁷

PG-42.1.3 ASME B16.3, Malleable Iron Threaded Fittings, Classes 150 and 300

PG-42.1.4 ASME B16.4, Gray Iron Threaded Fittings

PG-42.1.5 ASME B16.5, Pipe Flanges and Flanged Fittings (see PG-42.2)

¹⁷ Classes 25 and 800 are not applicable to Section I.

TABLE PG-39
MINIMUM NUMBER OF THREADS PER CONNECTION

CUSTOMARY UNITS								
Pressure up to and including 300 psi								
Size of pipe connection (NPS)	1 & 1¼	1½ & 2	2½ to 4	5 & 6	8	10	12	
Threads engaged	4	5	7	8	10	12	13	
Min. plate thickness required, in.	0.348	0.435	0.875	1.0	1.25	1.5	1.625	
Pressures above 300 psi								
Size of pipe connection, (NPS)	½ & ¾	1 to 1½	2	2½ & 3	4 to 6	8	10	12
Threads engaged	6	7	8	8	10	12	13	14
Min. plate thickness, required, in.	0.43	0.61	0.70	1.0	1.25	1.5	1.62	1.75
SI UNITS								
Pressure up to and including 2 070 kPa								
Size of pipe connection (DN)	25 & 32	40 & 50	65 to 100	125 & 150	200	10	12	
Threads engaged	4	5	7	8	10	12	13	
Min. plate thickness required (mm)	8.8	11.0	22.2	25.4	31.8	1.5	1.625	
Pressures above 2 070 kPa								
Size of pipe connection (DN)	15 & 20	25 to 40	50	65 & 80	100 to 150	200	250	300
Threads engaged	6	7	8	8	10	12	13	14
Min. plate thickness, required (mm)	10.9	15.5	17.8	25.4	31.8	38.1	1.62	1.75

PG-42.1.5.1 Pressure-Temperature Ratings per Table 2

PG-42.1.5.2 Facing Dimensions (other than ring-joint) per Table 4

PG-42.1.5.3 Facing Dimensions for Ring-Joint Flanges per Table 5

PG-42.1.5.4 Dimensions of Flanges for Pressure Rating Classes per Tables 8 through 28

PG-42.1.6 ASME B16.9, Factory-Made Wrought Steel Buttwelding Fittings

When pressure ratings are established under the provisions of para. 2.1 of ASME B16.9 they shall be calculated as for straight seamless pipe in accordance with ASME B31.1.

PG-42.1.7 ASME B16.11, Forged Fittings, Socket-Welding and Threaded (see PG-42.2)

PG-42.1.8 ASME B16.15, Cast Bronze Threaded Fittings, Classes 125 and 250 (see PG-8.4 and PG-4.11)

PG-42.1.9 ASME B16.20, Ring-Joint Gaskets and Grooves for Steel Pipe Flanges

PG-42.1.10 ASME B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings (see PG-8.4)

PG-42.1.11 ASME B16.25, Buttwelding Ends

PG-42.1.12 ASME B16.34, Valves — Flanged, Threaded, and Welding End (see PG-42.2 and PG-42.4.3)

PG-42.1.13 ASME B16.28, Wrought Steel Buttwelding Short Radius Elbows and Returns

PG-42.1.14 ASME B16.42, Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300 (see PG-8.3)

PG-42.2 Marking. All valves and fittings shall be marked with the name, trademark, or other identification of the manufacturer and the primary service pressure rating except that the pressure rating marking may be omitted from:

PG-42.2.1 Cast iron threaded fittings for Class 125 working pressure

PG-42.2.2 Malleable iron threaded fittings for Class 150 working pressure

PG-42.2.3 Nonferrous threaded fittings for Classes 125 and 250 working pressure

PG-42.2.4 Cast iron and nonferrous companion flanges

PG-42.2.5 Additional markings for butt welding fittings, as called for by several Code Standards for all valves and fittings, are recommended if the size and shape of the valve or fitting permit.

PG-42.3 Flange Materials. Flanges shall be made of materials permitted by this Section or of materials specifically listed in the applicable product standards listed in PG-42.1, but not of materials specifically prohibited or beyond the use limitations listed in this Section. Rolled or forged flanges may be made from material conforming to any forging specification among these permitted materials, except that SA-181 shall not be used for flanges whose pressure rating is higher than Class 300. Hub-type flanges shall not be cut or machined from plate material.

PG-42.4 Additional Requirements. Flanges made of other materials permitted under this Section shall be at least equal to the strength requirements, and the facing dimensions and bolt circles shall agree with the Standard otherwise required.

PG-42.4.1 The thickness of all fitting and valve bodies subject to pressure shall be not less than that required by the applicable ASME Standard listed in PG-42.1 for the corresponding maximum allowable working pressure and temperature for the material used. The cylindrical ends of cast steel welding end valves and fittings conforming to ASME B16.5 or B16.34 may be proportioned with a casting quality factor of 100% provided these areas are finish-machined both inside and outside, are carefully inspected, and that the contour of the welding end transition complies with PG-42.4.2.

PG-42.4.2 The welding ends of component bodies such as fittings and valves, whether constructed of cast products, wrought products, or any other fabrication process acceptable under the Code, shall provide a gradual change in thickness from that of the adjoining pipe to that of the component body. Any configuration of weld end transition that lies entirely within the envelope shown in Fig. PG-42.1 is acceptable provided that:

(a) the wall thickness in the transition region is not less than the smaller of the fitting or valve thickness required by PG-42.4.1 or the minimum value of the pipe thickness $t_{\min}$ defined under Fig. PG-42.1;

(b) the transition region including the weld joint shall avoid sharp reentrant angles and abrupt changes in slope. When the included angle between any two adjoining surfaces of a taper transition is less than 150 deg., the intersection or corner (except for the weld

reinforcement) shall be provided with a radius of at least $0.05 t_{\min}$.

The configurations and tolerances suggested by such weld end standards as ASME B16.9 and ASME B16.25 are acceptable only to the extent that the resulting product and weld joint will comply with these requirements of PG-42.4.2. In Fig. PG-42.1 the thickness in the plane at the end of the fitting or valve shall not be less than $t_{\min}$ and shall not exceed a maximum of either: the greater of [$t_{\min} + 0.15$ in. (4 mm)] or $1.15 t_{\min}$ when ordered on a minimum wall basis, or the greater of [$t_{\min} + 0.15$ in. (4 mm)] or $1.10 t_{\text{nom}}$ when ordered on a nominal wall basis.

PG-42.4.3 Fittings in which there are minor changes in the center-to-face dimensions or in which the angles of elbows differ from those given in an ASME Standard in PG-42.1 may be considered to fall within the scope of the standard provided the other requirements for materials, dimensions, and thickness are met.

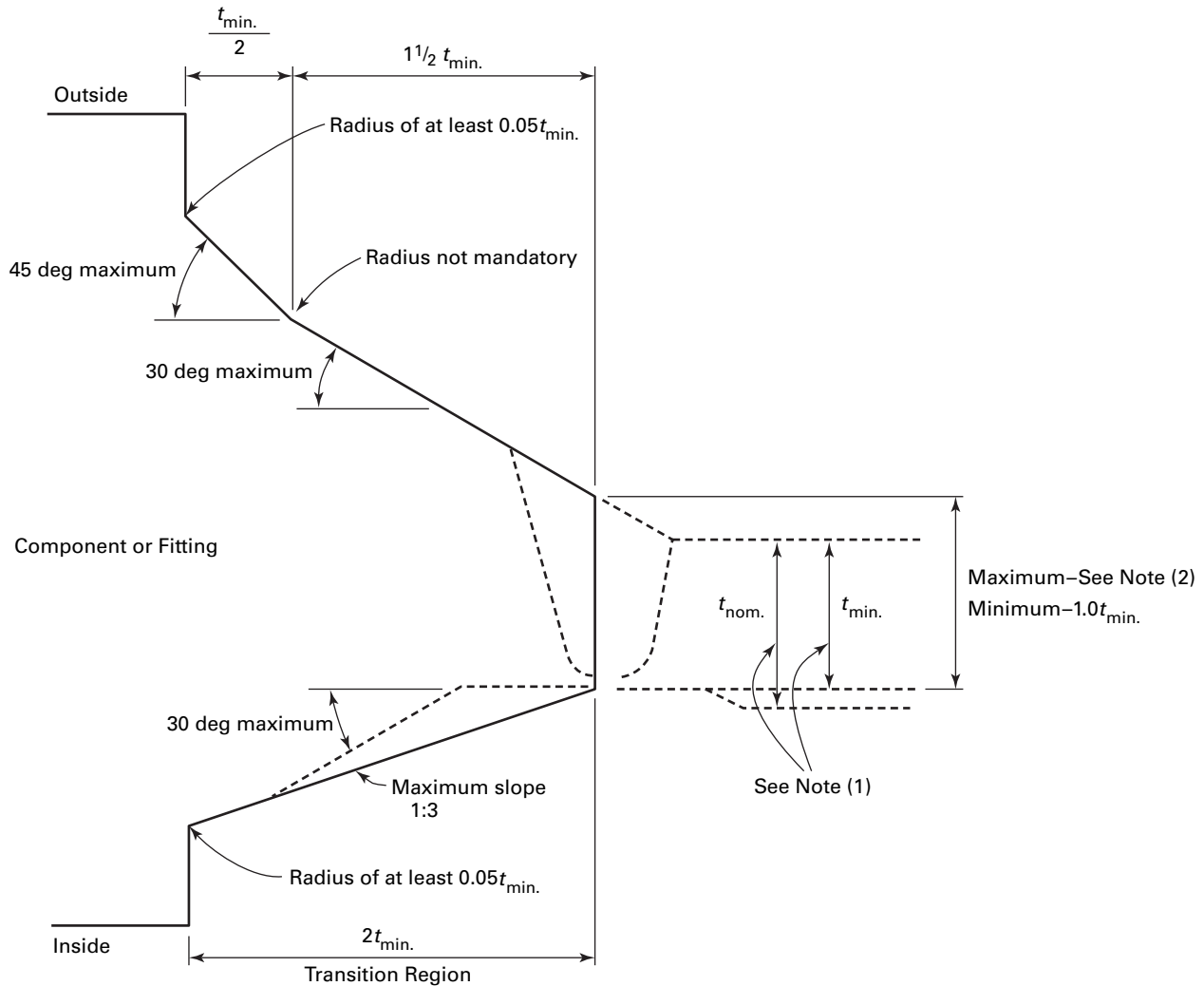
PG-42.4.4 Flanges and flanged fittings meeting the requirements of ASME B16.5 or valves meeting the requirements of ASME B16.34 may be used at the pressure-temperature ratings established by those standards. Standard Class, Special Class, or Limited Class valves may be used, provided that all parts of the valves are suitable for the pressure-temperature conditions at which they are to be used. Valves of intermediate rating or class, as described in ASME B16.34, are permitted.

PG-42.4.5 When the service requirements exceed the permissible values given in ASME B16.5 or ASME B16.34, the requirements of the Code will be met if the bolting material, flange thickness, and/or body thickness are increased so that the deflection limits are no greater and the factor of safety is no less than that of the nearest Pressure Rating Class in ASME B16.5 or ASME B16.34.

PG-42.4.6 Steel butt welding fittings may be used provided they are at least equal to the requirements of ASME B16.9.

PG-42.4.7 ASME Standard slip-on flanges shall not exceed NPS 4 (DN 100). Attachment of slip-on flanges shall be by double fillet welds. The throats of the fillet welds shall not be less than 0.7 times the thickness of the part to which the flange is attached.

PG-42.4.8 ASME Standard socket welded flanges may be used in piping or boiler nozzles provided the dimensions do not exceed NPS 3 (DN 80) for Class



GENERAL NOTES:

- Weld bevel is shown for illustration only.
- The weld reinforcement permitted by PW-35 may be outside the maximum envelope.

NOTES:

- The value of $t_{min.}$ is whichever of the following is applicable:
 - the minimum ordered wall thickness of the pipe; or
 - the minimum ordered wall thickness of the tube; or
 - 0.875 times the nominal wall thickness of pipe ordered to a pipe schedule wall thickness that has an undertolerance of 12.5°; or
 - the minimum ordered wall thickness of the cylindrical welding end of a component or fitting (or the thinner of the two) when the joint is between two components.
- The maximum thickness at the end of the component is:
 - the greater of $[t_{min.} + 0.15 \text{ in. (4mm)}]$ or $1.15t_{min.}$ when ordered on a minimum wall basis;
 - the greater of $[t_{min.} + 0.15 \text{ in. (4mm)}]$ or $1.10t_{nom.}$ when ordered on a nominal wall basis.

FIG. PG-42.1 WELDING END TRANSITIONS MAXIMUM ENVELOPE

600 and lower, and NPS 2½ (DN 65) in Classes 900 and 1,500.

PG-42.4.9 Threaded fittings of cast iron or malleable iron conforming to the requirements of the ASME Standards for Classes 125, 150, 250, and 300 pressure may be used except where otherwise specifically prohibited or where flanged fittings are specifically required. They shall not be used for temperatures over 450°F (232°C).

PG-42.4.10 Cast- or forged-steel threaded fittings or valves that are at least equal to the strength requirements of the ASME Standard fittings that would otherwise be required may be used in all cases except where flanged fittings are specifically required.

PG-42.4.11 The casting quality factors given in PG-25 do not apply to ASME Standard cast steel fittings whose dimensions and ratings are incorporated in the Code.

Bronze threaded or flanged type fittings or valves may be used provided they are at least equal to the strength requirements of ASME B16.1 cast iron fittings that would otherwise be required. Bronze threaded fittings may be used if they comply with ASME B16.15. The material shall comply with PG-8.4 and the allowable working stresses are not to exceed the values given in Table 1B of Section II, Part D, except as provided in PG-67.7. Bronze shall not be used where steel or other material is specifically required. Threaded type fittings shall not be used where flanged types are specified.

PG-43 NOZZLE NECK THICKNESS

The thickness of a nozzle neck used in a compensated opening shall not be less than the thickness required for the applicable loadings, but in no case less than the smaller of the following:

PG-43.1 The thickness of a seamless shell or head to which it is attached.

PG-43.2 The thickness of standard-wall pipe for pipe nozzles or the required minimum thickness of a tube nipple based on 600 psi (4 140 kPa) internal pressure.

PG-44 INSPECTION OPENINGS

PG-44.1 All boilers or parts thereof shall be provided with suitable manhole, handhole, or other inspection openings for examination or cleaning, except for special

types of boilers where such openings are manifestly not needed or used.

Specific requirements for access openings in certain types of boilers appear in other paragraphs.

An elliptical manhole opening shall be not less than 12 in. × 16 in. (152 mm × 406 mm) in size.

A circular manhole opening shall be not less than 15 in. (381 mm) in diameter.

A handhole opening in a boiler drum or shell shall be not less than 2¾ in. × 3½ in. (70 mm × 89 mm), but it is recommended that, where possible, larger sizes be used.

Manhole, handhole, inspection, and washout openings in a shell or unstayed head shall be designed in accordance with the rules of PG-32 to PG-42.

When a threaded opening is to be used for inspection or washout purposes, it shall be not less than 1 in. (25 mm) pipe size. The closing plug or cap shall be of nonferrous material except for pressures of over 250 psi (1 720 kPa).

The thread shall be a standard tapered pipe thread, except that a straight thread of equal strength may be used if other sealing surfaces to prevent leakage are provided.

PG-44.2 Manhole and handhole cover plates shall be of rolled, forged or cast steel except that for pressures not exceeding 250 psi (1 720 kPa), and/or temperatures not exceeding 450°F (232°C), handhole cover plates may be made of cast iron complying with SA-278. Yokes, if used, shall be made of rolled, forged, or cast steel.

The strength of all such parts together with the bolts and yokes, if any, shall be proportioned for the service for which they are used.

PG-44.3 The minimum width of bearing surface for a gasket on a manhole opening shall be 11/16 in. (18 mm). No gasket for use on a manhole or handhole of any boiler shall have a thickness greater than ¼ in. (6 mm), when compressed.

PG-46 STAYED SURFACES

PG-46.1 The minimum thickness and maximum allowable working pressure for stayed flat plates and those parts that, by these rules, require staying as flat plates with stays or staybolts of uniform diameter symmetrically spaced, shall be calculated by the following formulas:

$$t = p \sqrt{\frac{P}{SC}} \quad (1)$$

$$P = \frac{t^2 SC}{p^2} \quad (2)$$

where

- t = minimum thickness of plate, in. (mm)
- P = maximum allowable working pressure, psi (kPa)
- S = maximum allowable stress given in Table 1A of Section II, Part D, psi (kPa)
- p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal and vertical, or radial and circumferential, in. (mm)
- $C = 2.1$ for welded stays or stays screwed through plates not over $\frac{7}{16}$ in. (11 mm) in thickness with ends riveted over
- $C = 2.2$ for welded stays or stays screwed through plates over $\frac{7}{16}$ in. (11 mm) in thickness with ends riveted over
- $C = 2.5$ for stays screwed through plates and fitted with single nuts outside of plate, or with inside and outside nuts, omitting washers
- $C = 2.8$ for stays with heads not less than 1.3 times the diameter of the stays screwed through plates or made a taper fit and having the heads formed on the stay before installing them, and not riveted over, said heads being made to have a true bearing on the plate
- $C = 3.2$ for stays fitted with inside and outside nuts and outside washers where the diameter of washers is not less than $0.4p$ and thickness not less than t

PG-46.2 The minimum thickness of plates to which stays may be applied, in other than cylindrical or spherical outer shell plates, shall be $\frac{5}{16}$ in. (8 mm) except for welded construction covered by PW-19.

PG-46.3 When two plates are connected by stays and only one of these plates requires staying, the value of C shall be governed by the thickness of the plate requiring staying.

PG-46.4 Acceptable proportions for the ends of through-stays with washers are indicated in Fig. PG-46.2.

PG-46.5 The maximum pitch shall be $8\frac{1}{2}$ in. (216 mm) except that for welded-in staybolts the pitch

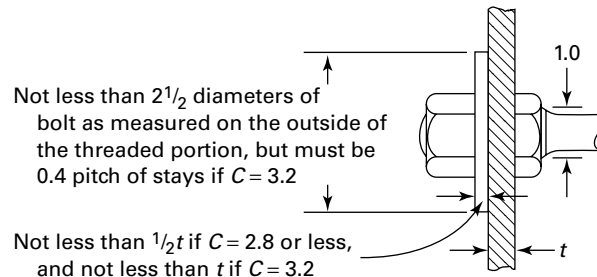


FIG. PG-46.2 ACCEPTABLE PROPORTIONS FOR ENDS OF THROUGH-STAYS

may be greater provided it does not exceed 15 times the diameter of the staybolt.

For the application of PG-48 and PFT-26, see Fig. A-8.

PG-46.6 Where the staybolting of shells is unsymmetrical by reason of interference with butt straps or other construction, it is permissible to consider the load carried by each staybolt as the area calculated by taking the distance from the center of the spacing on one side of the bolt to the center of the spacing on the other side.

PG-46.7 The ends of stays fitted with nuts shall not be exposed to the direct radiant heat of the fire.

PG-46.8 Stays exceeding 120 diameters in length shall be supported at intervals not exceeding 120 diameters, or the cross-sectional area of the stay shall be increased by not less than 15% of its required area.

PG-47 STAYBOLTS

PG-47.1 The ends of staybolts or stays screwed through the plate shall extend beyond the plate not less than two threads when installed, after which they shall be riveted over or upset by an equivalent process without excessive scoring of the plates; or they shall be fitted with threaded nuts through which the bolt or stay shall extend. The outside ends of solid staybolts 8 in. (203 mm) and less in length, if of uniform diameter throughout their length, shall be drilled with telltale holes at least $\frac{3}{16}$ in. (4.8 mm) in diameter to a depth extending at least $\frac{1}{2}$ in. (13 mm) beyond the inside of the plate. If such staybolts are reduced in section between their ends below their diameter at the root of the thread, the telltale holes shall extend at least $\frac{1}{2}$ in. (13 mm) beyond the point where the reduction in section commences. Hollow staybolts may

be used in place of solid staybolts with drilled ends. Solid staybolts over 8 in. (203 mm) long and flexible staybolts of either the jointed or ball-and-socket type need not be drilled. Staybolts used in waterlegs of watertube boilers shall be hollow or drilled at both ends, in accordance with the requirements above stated, irrespective of their length. All threaded staybolts not normal to the stayed surface shall have not less than three engaging threads of which at least one shall be a full thread, but if the thickness of the material in the boiler is not sufficient to give one full engaging thread, the plates shall be sufficiently reinforced on the inside by a steel plate welded thereto. Telltale holes are not required in staybolts attached by welding.

PG-47.2 The ends of steel stays upset for threading shall be fully annealed after upsetting.

PG-47.3 Requirements for welded-in staybolts are given in PW-19.

PG-48 LOCATION OF STAYBOLTS

PG-48.2 When the edge of a flat stayed plate is flanged, the distance from the center of the outermost stays to the inside of the supporting flange shall not be greater than the pitch of the stays plus the inside radius of the flange.

PG-49 DIMENSIONS OF STAYBOLTS

PG-49.1 The required area of a staybolt at its minimum cross section shall be obtained by dividing the load on the staybolt, computed in accordance with PFT-26, by the allowable stress value in accordance with Table 1A of Section II, Part D, and multiplying the results by 1.10.

PG-49.2 The diameter of a screw stay shall be taken at the bottom of the thread or wherever it is of the least diameter.

PG-52 LIGAMENTS

PG-52.1 The rules of this paragraph apply to groups of openings that form a definite pattern in pressure parts. (For patterns not definite see PG-53.) The efficiency of the ligament between the tube holes shall be determined as follows.

PG-52.2 Openings Parallel to Vessel Axis

PG-52.2.1 When the pitch of the tubes on every tube row is equal (as in Fig. PG-52.2), the formula is:

$$E = \frac{p - d}{p}$$

Example: Pitch of tube holes in the drum as shown in Fig. PG-52.2 = $5\frac{1}{4}$ in. Diameter of tube = $3\frac{1}{4}$ in. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p - d}{p} = \frac{5.25 - 3.281}{5.25}$$

$$= 0.375 \text{ efficiency of ligament}$$

PG-52.2.2 When the pitch of the tube holes on any one row is unequal (as in Fig. PG-52.3 or PG-52.4), the formula is:

$$E = \frac{p_1 - nd}{p_1}$$

Example: Spacing shown in Fig. PG-52.3. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p_1 - nd}{p_1} = \frac{12 - 2 \times 3.281}{12}$$

$$= 0.453 \text{ efficiency of ligament}$$

Example: Spacing shown in Fig. PG-52.4. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p_1 - nd}{p_1} = \frac{29.25 - 5 \times 3.281}{29.25}$$

$$= 0.439 \text{ efficiency of ligament}$$

PG-52.3 Openings Transverse to Vessel Axis. The strength of those ligaments between the tube holes that are subjected to a longitudinal stress shall be at least one-half the required strength of those ligaments that come between the tube holes that are subjected to a circumferential stress.

PG-52.4 Holes Along a Diagonal. When a shell or drum is drilled for tube holes as shown in Fig. PG-52.5, the efficiency of these ligaments shall be that given by the diagram in Fig. PG-52.1. The abscissa $(p - d)/p$ and the ratio p'/p shall be computed. With these values the efficiency may be read off the ordinate. Should the point fall above the curve of equal efficiency for the diagonal and longitudinal ligaments, the longitu-

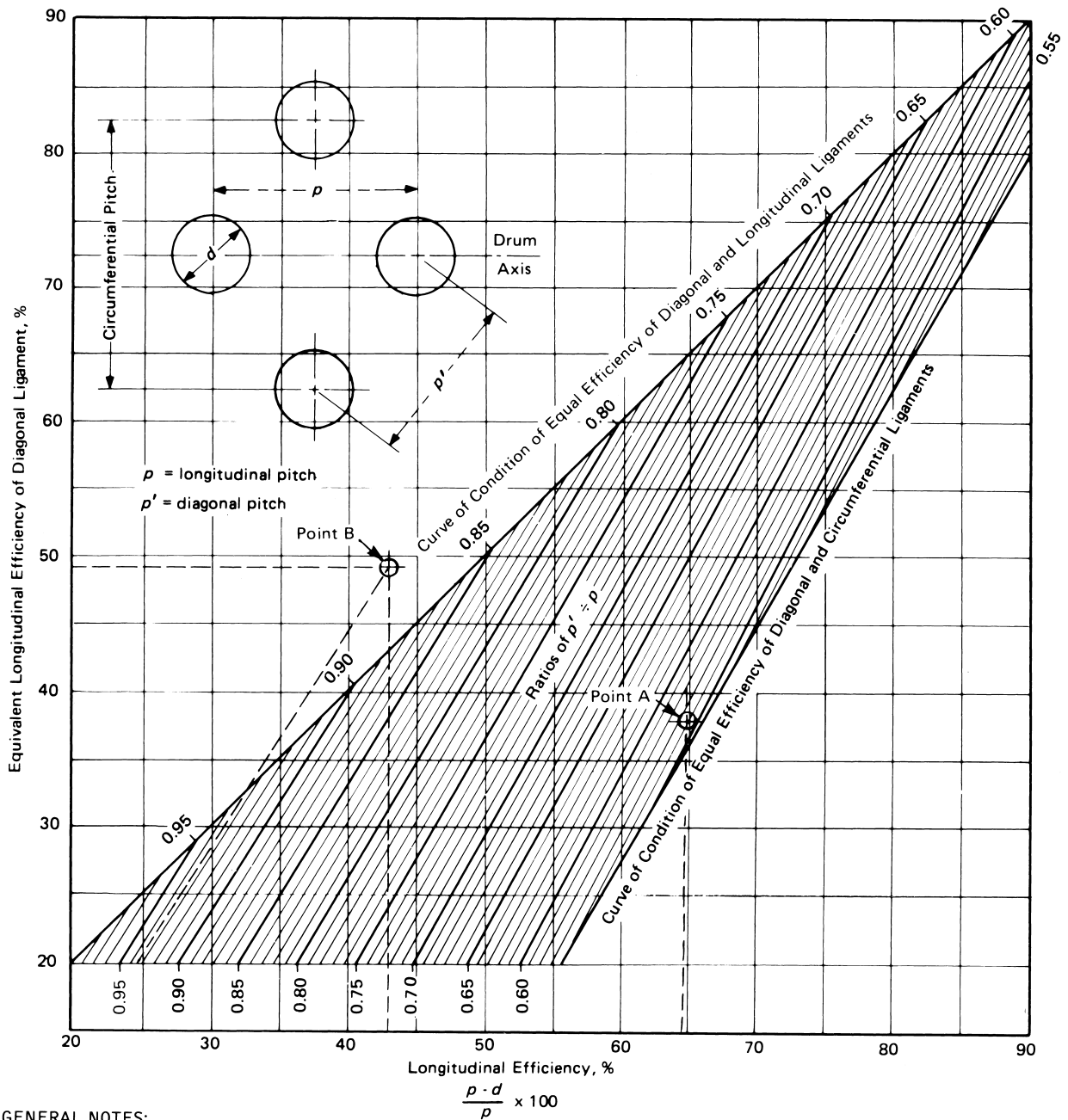


FIG. PG-52.1 DIAGRAM FOR DETERMINING THE EFFICIENCY OF LONGITUDINAL AND DIAGONAL LIGAMENTS BETWEEN OPENINGS IN CYLINDRICAL SHELLS

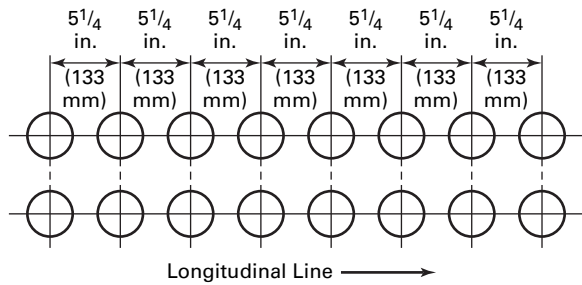


FIG. PG-52.2 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES EQUAL IN EVERY ROW

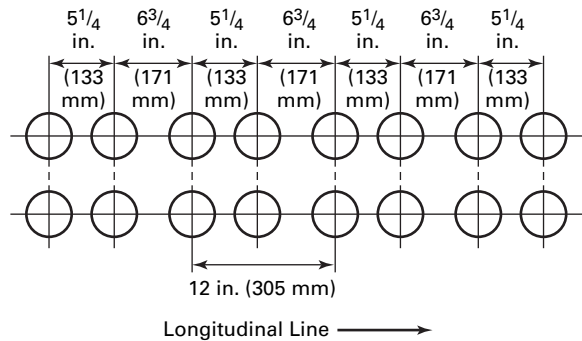


FIG. PG-52.3 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES UNEQUAL IN EVERY SECOND ROW

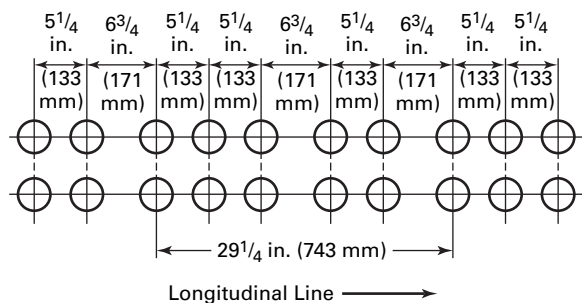


FIG. PG-52.4 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES VARYING IN EVERY SECOND AND THIRD ROW

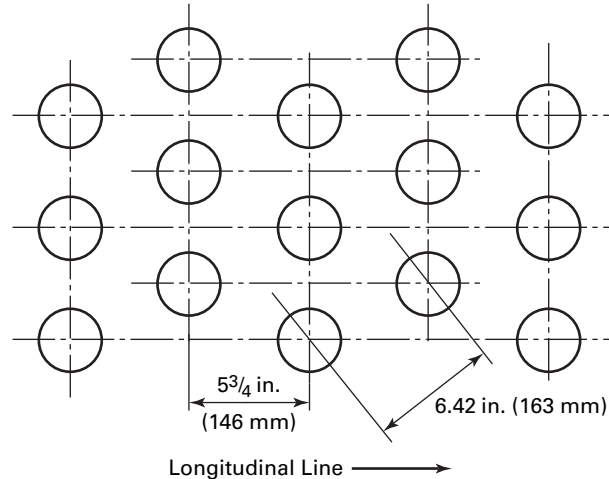


FIG. PG-52.5 EXAMPLE OF TUBE SPACING WITH TUBE HOLES ON DIAGONAL LINES

dinal ligaments will be the weaker, in which case the efficiency is computed from the following equation:

$$\frac{p - d}{p} \quad (1)$$

Example:

(1) Diagonal pitch of tube holes in drum as shown in Fig. PG-52.5 = 6.42 in. Diameter of holes = $4\frac{1}{32}$ in. Longitudinal pitch of tube holes = $11\frac{1}{2}$ in.

$$\frac{p - d}{p} = \frac{11.5 - 4.031}{11.5} = 0.649 \quad (2)$$

$$\frac{p'}{p} = \frac{6.42}{11.5} = 0.558 \quad (3)$$

The point corresponding to these values is shown at A on the diagram in Fig. PG-52.1, and the corresponding efficiency is 37.0%. As the point falls below the curve of equal efficiency for the diagonal and longitudinal ligaments, the diagonal ligament is the weaker.

(2) Diagonal pitch of tube holes in drum = $6\frac{35}{64}$ in. Diameter of tube holes = $4\frac{1}{64}$ in. Longitudinal pitch of tube holes = 7 in.

$$\frac{p - d}{p} = \frac{7 - 4.0156}{7} = 0.426 \quad (4)$$

$$\frac{p'}{p} = \frac{6.547}{7} = 0.935$$

The point corresponding to these values is shown at *B* on the diagram in Fig. PG-52.1, and it will be seen that it falls above the line of equal efficiency for the diagonal and longitudinal ligaments, in which case the efficiency is computed from Eq. (1). Applying Eq. (1), we have:

$$\frac{7 - 4.0156}{7} = 0.426, \text{ efficiency of ligament, or } 42.6\%$$

PG-52.5 When tubes or holes are arranged in a drum or shell in symmetrical groups along lines parallel to the axis and the same spacing is used for each group, the efficiency for one of the groups shall be not less than the efficiency on which the maximum allowable working pressure is based.

PG-52.6 The symbols defined below are used in the formulas of this paragraph:

p = longitudinal pitch of adjacent openings, in. (mm)

p' = diagonal pitch of adjacent openings, in. (mm)

p_1 = pitch between corresponding openings in a series of symmetrical groups of openings, in. (mm)

d = diameter of openings, in. (mm)

n = number of openings in length p_1

E = efficiency of ligament

The pitch shall be measured either on the flat plate before rolling or on the median surface after rolling.

PG-53 LIGAMENTS

PG-53.1 The rules in this paragraph apply to groups of openings that do not form a definite pattern in pressure parts. (For definite patterns see PG-52.) The efficiency of the ligament between tube holes shall be determined as follows:

PG-53.2 When tubes or holes are unsymmetrically spaced, the average ligament efficiency shall be not less than that given by the following rules, which apply to ligaments between tube holes, and not to single openings. This procedure may give lower efficiencies in some cases than those for symmetrical groups which extend a distance greater than the inside diameter of the shell as covered under PG-52. When this occurs, the efficiencies computed by the rules under PG-52 shall be used.

PG-53.2.1 For a length equal to the inside diameter of the drum for the position that gives the minimum

efficiency, the efficiency shall be not less than that on which the maximum allowable working pressure is based. When the diameter of the drum exceeds 60 in. (1 520 mm), the length shall be taken as 60 in. (1 520 mm) in applying this rule.

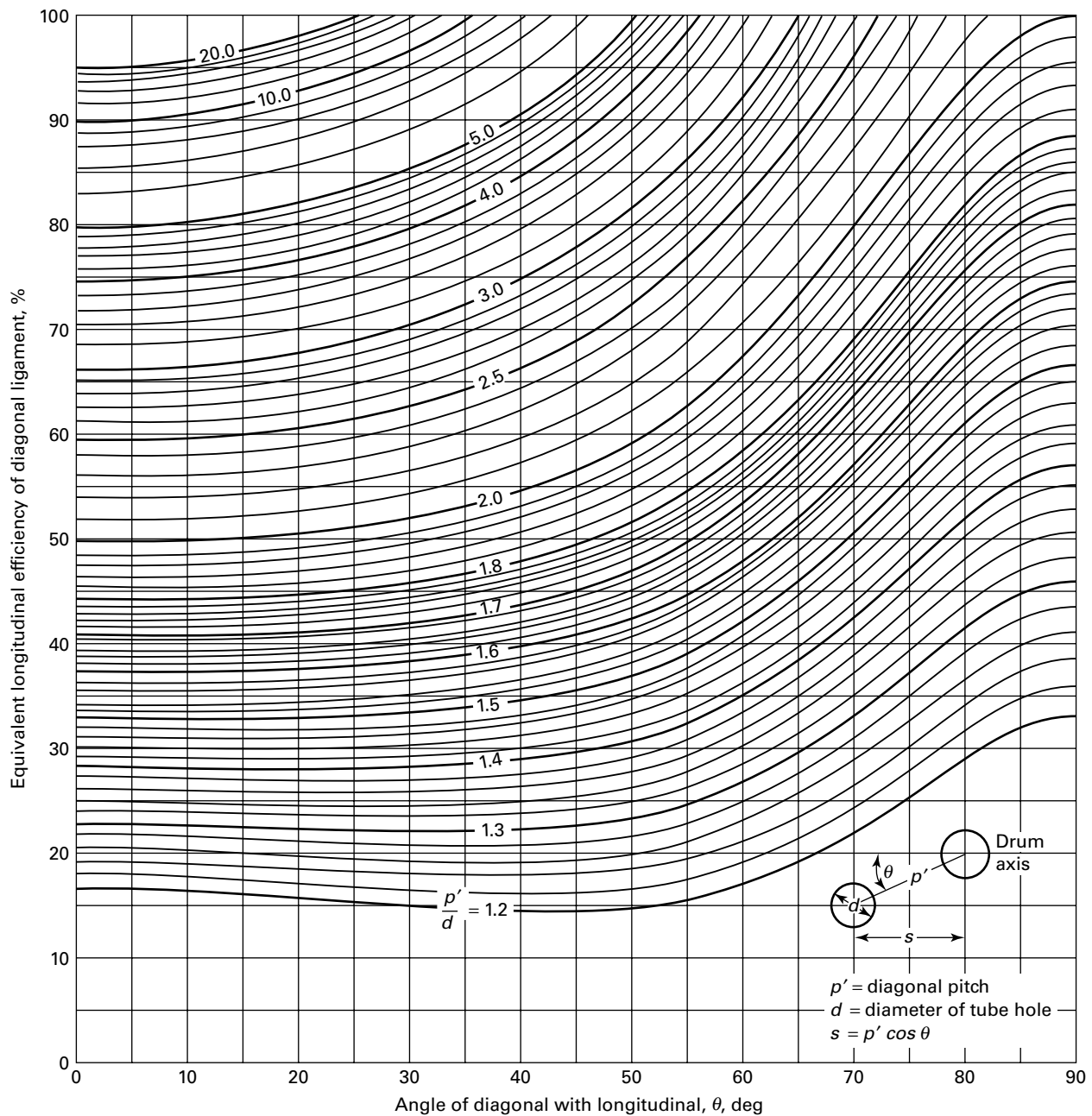
PG-53.2.2 For a length equal to the inside radius of the drum for the position that gives the minimum efficiency, the efficiency shall be not less than 80% of that on which the maximum allowable working pressure is based. When the radius of the drum exceeds 30 in. (762 mm), the length shall be taken as 30 in. (762 mm) in applying this rule.

PG-53.3 For holes placed longitudinally along a drum but that do not come in a straight line, the above rules for calculating efficiency shall hold except that the equivalent longitudinal width of a diagonal ligament shall be used. To obtain the equivalent width the longitudinal pitch of the two holes having a diagonal ligament shall be multiplied by the efficiency of the diagonal ligament. The efficiency to be used for the diagonal ligaments is given in Fig. PG-52.6.

PG-55 SUPPORTS AND ATTACHMENT LUGS

PG-55.1 Lugs or hangers when used to support a boiler of any type shall be properly fitted to the surfaces to which they are attached.

PG-55.2 Lugs, hangers, or brackets may be attached by fusion welding provided the welding meets the requirements of Part PW, including stress relieving but omitting radiographic examination and provided they are attached by full penetration welds, combination groove and fillet welds, or by fillet welds along the entire periphery or contact edges. Some acceptable forms of welds for lugs, hangers, or brackets are shown in Fig. PW-16.2. The materials for lugs, hangers, or brackets are not limited to those listed in Tables 1A and 1B of Section II, Part D, but shall be of weldable quality. The allowable load on the fillet welds shall equal the product of the weld area based on minimum leg dimension, the allowable stress value in tension of the material being welded, and the factor 0.55. When using welded pipe, the stress values given in Table 1A of Section II, Part D, may be increased to that of the basic material by eliminating the stated weld efficiencies.



GENERAL NOTES:

- (a) The equation in Note (b) below is provided for the user's option. The use of the equation is prohibited beyond the range of the abscissa and ordinate shown.
- (b) Equivalent longitudinal efficiency,

$$\% = \frac{\sec^2 \theta + 1 - \left(\frac{\sec \theta}{p'/d} \right) \sqrt{3 + \sec^2 \theta}}{0.015 + 0.005 \sec^2 \theta}$$

FIG. PG-52.6 DIAGRAM FOR DETERMINING EQUIVALENT LONGITUDINAL EFFICIENCY OF DIAGONAL LIGAMENTS BETWEEN OPENINGS IN CYLINDRICAL SHELLS

BOILER EXTERNAL PIPING AND BOILER PROPER CONNECTIONS

PG-58 OUTLETS AND EXTERNAL PIPING

PG-58.1 General. The rules of this subparagraph apply to the boiler external piping as defined in the Preamble.

PG-58.2 Boiler External Piping Connections to Boilers. All boiler external piping connected to a boiler for any purpose shall be attached to one of the types of joints listed in PG-59.1.1.1, PG-59.1.1.2, and PG-59.1.1.3.

PG-58.3 Boiler External Piping. The following defines the Code Jurisdictional Limits of the boiler external piping systems, including general requirements, valves, and inspection. The limits are also shown in Fig. PG-58.3.1 and Fig. PG-58.3.2. The materials, design, fabrication, installation, and testing shall be in accordance with ASME B31.1, Power Piping.

PG-58.3.1 The steam piping connected to the boiler drum or to the superheater outlet header shall extend up to and including the first stop valve in each connection, except as required by PG-58.3.2. In the case of a single boiler and prime mover installation, the stop valve required herein may be omitted provided the prime mover throttle valve is equipped with an indicator to show whether the valve is open or closed and is designed to withstand the required hydrostatic pressure test of the boiler.

For an isolable or separately fired superheater which discharges steam directly to a process stream, the stop valve required by this paragraph and the safety valve(s) required by PG-68 may be omitted provided the following conditions are satisfied:

(a) The boiler is a drum-type boiler in a single-boiler installation.

(b) The steam discharge passes through the process stream to the atmosphere with no intervening valves.

(c) The system shall be designed so that the process stream through which the steam discharge passes cannot be obstructed in such a way as to cause the pressure in the superheater to exceed that permitted by PG-67.2, with maximum steam flow from the boiler to the superheater. Flow and pressure calculations demonstrating that the superheater will not be overpressurized under any steam flow conditions shall be documented and made available to the Inspector. These calculations shall be certified by a Professional Engineer experienced in the mechanical design of power plants.

(d) There is no valve on the discharge side of the superheater.

(e) Section I jurisdiction shall include the pressure parts between the superheater inlet and the outlet at:

(1) the first circumferential joint for welding end connections; or

(2) the face of the first flange in bolted flange connections; or

(3) the first threaded joint in that type of connection.

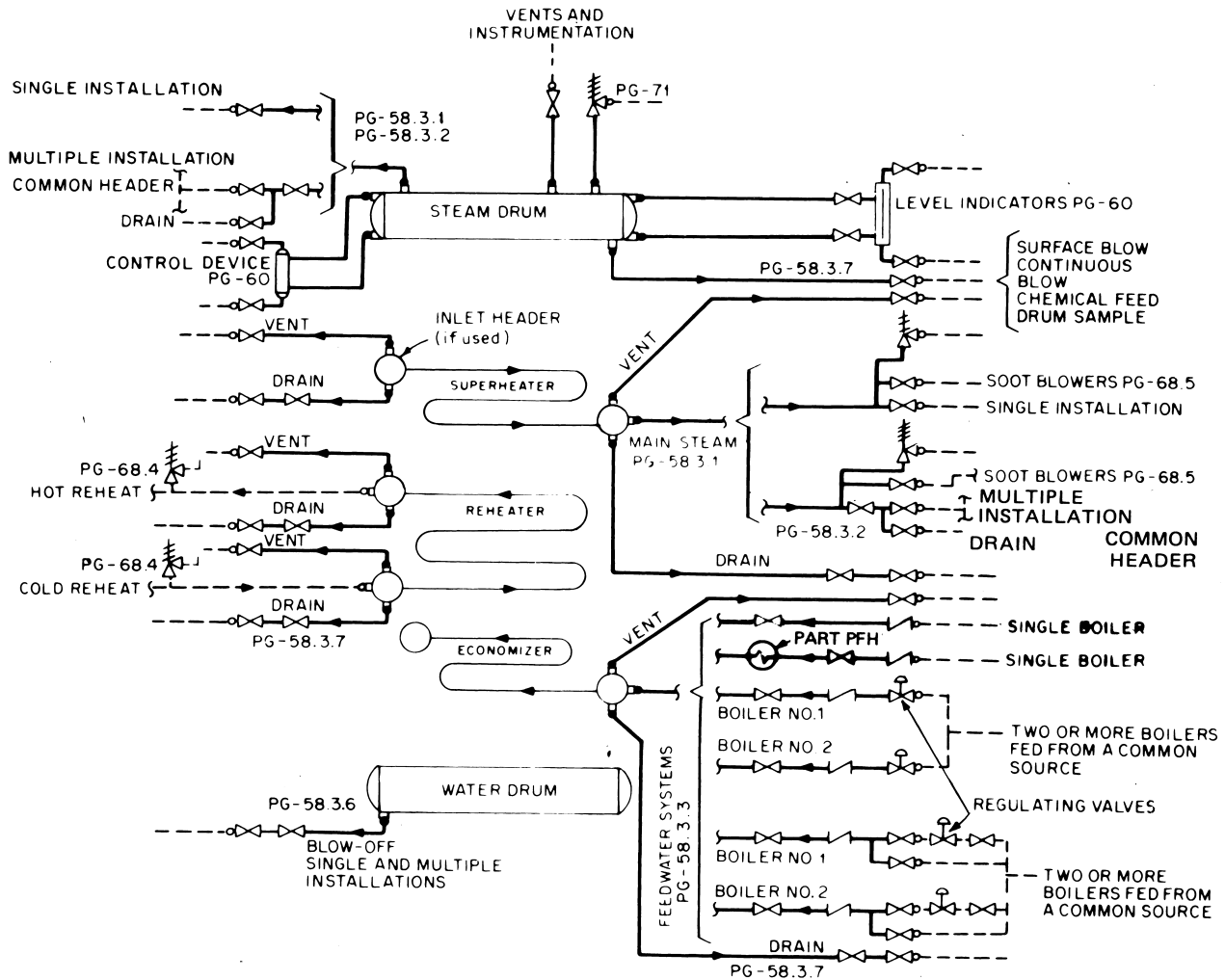
PG-58.3.2 When two or more boilers are connected to a common steam header, or when a single boiler is connected to a header having another steam source (e.g., a turbine extraction line), the connection from each boiler having a manhole opening shall be fitted with two stop valves having an ample free-blow drain between them. The boiler external piping includes all piping from the boiler proper up to and including the second stop valve and the free-blow drain valve.

PG-58.3.3 The feedwater piping for all boilers, except high-temperature water boilers and forced-flow steam generators complying with PG-58.3.5, shall extend through the required stop valve and up to and including the check valve except as required by PG-58.3.4. On a single boiler-turbine unit installation the boiler feed shutoff valve may be located upstream from the boiler feed check valve.

If a feedwater heater or heaters meeting the requirements of Part PFH are installed between the required stop valve and the boiler, and are fitted with isolation and bypass valves, provisions must be made to prevent the feedwater pressure from exceeding the maximum allowable working pressure of the piping or feedwater heater, whichever is less. Control and interlock systems are permitted in order to prevent overpressure.

PG-58.3.4 When two or more boilers are fed from a common source, the piping shall be up to and including a globe or regulating valve located between the check valve required in PG-58.3.3 and the source of supply. If the regulating valve is equipped with an isolation valve and a bypass valve, the piping shall be up to and including both the isolation valve downstream from the regulating valve and the shutoff valve in the bypass.

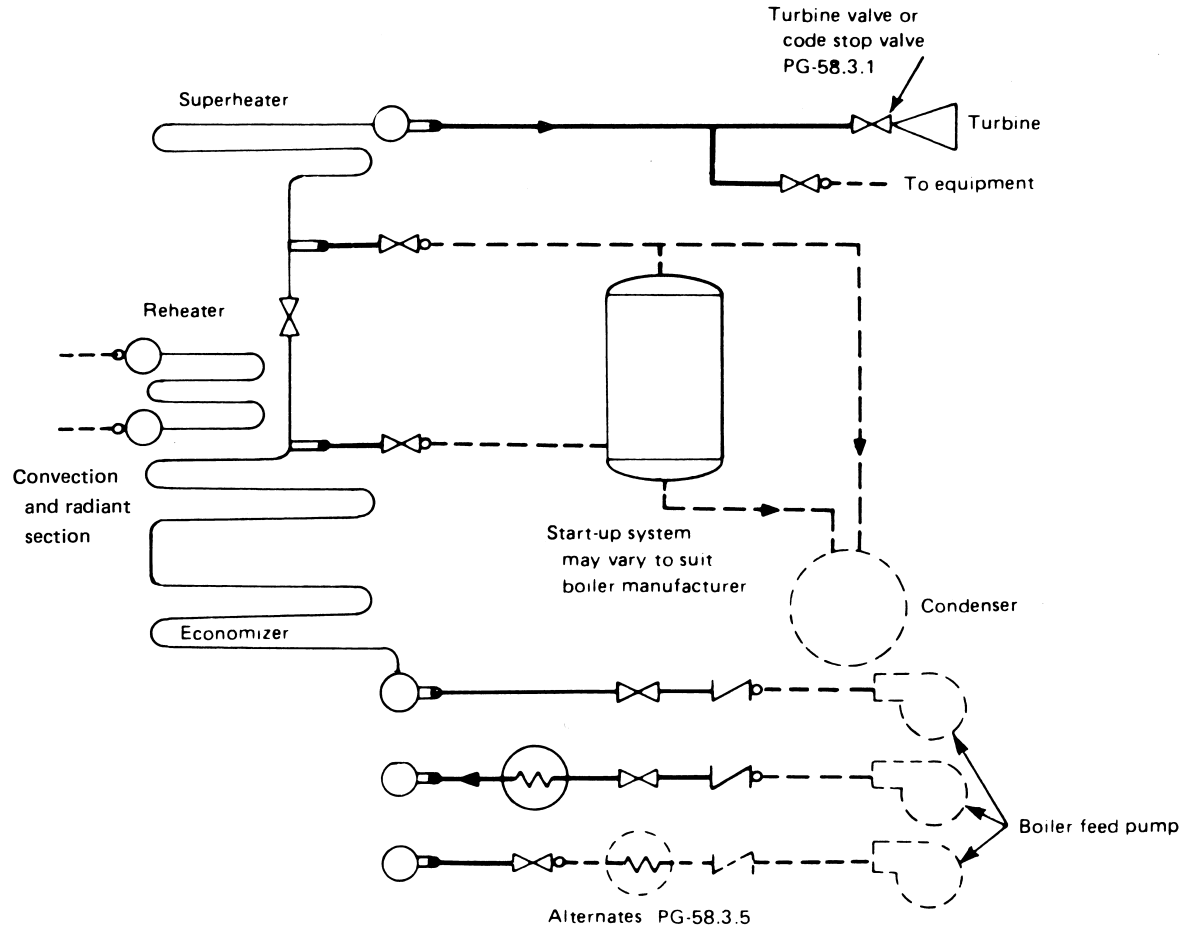
PG-58.3.5 The feedwater piping for a forced-flow steam generator with no fixed steam and waterline may terminate up to and including the stop valve near the boiler and omitting the check valve near the boiler, provided that a check valve having a pressure rating no less than the boiler inlet design pressure is installed



ADMINISTRATIVE JURISDICTION & TECHNICAL RESPONSIBILITY

- Boiler Proper — The ASME Boiler and Pressure Vessel Code (ASME BPVC) has total administrative jurisdiction and technical responsibility (refer to Section I Preamble).
- Boiler External Piping and Joint — The ASME BPVC has total administrative jurisdiction (mandatory certification by Code Symbol stamping, ASME Data Forms, and Authorized Inspection) of Boiler External Piping and Joint. The ASME Section Committee B31.1 has been assigned technical responsibility.
- Non-Boiler External Piping and Joint — Not Section I jurisdiction (see applicable ASME B31 Code).

FIG. PG-58.3.1 CODE JURISDICTIONAL LIMITS FOR PIPING — DRUM TYPE BOILERS



ADMINISTRATIVE JURISDICTION & TECHNICAL RESPONSIBILITY

- Boiler Proper — The ASME Boiler and Pressure Vessel Code (ASME BPVC) has total administrative jurisdiction and technical responsibility (refer to Section I Preamble).
- Boiler External Piping and Joint — The ASME BPVC has total administrative jurisdiction (mandatory certification by Code Symbol stamping, ASME Data Forms, and Authorized Inspection) of Boiler External Piping and Joint. The ASME Section Committee B31.1 has been assigned technical responsibility.
- Non-Boiler External Piping and Joint — Not Section I jurisdiction (see applicable ASME B31 Code).

FIG. PG-58.3.2 CODE JURISDICTIONAL LIMITS FOR PIPING — FORCED-FLOW STEAM GENERATOR WITH NO FIXED STEAM OR WATERLINE

at the discharge of the boiler feed pump or elsewhere in the feedline between the feed pump and the feed stop valve. If the feedwater heater(s) is fitted with isolation and bypass valves, the applicable requirements of PG-58.3.3 must be met.

PG-58.3.6 The blowoff piping for all boilers, except forced-flow steam generators with no fixed steam and waterline, high-temperature water boilers, and those used for traction and/or portable purposes, when the maximum allowable working pressure exceeds 100 psi (690 kPa) shall extend through and including the second valve. The blowoff piping for all traction and/or portable boilers and for forced circulation and electric boilers having a normal water content not exceeding 100 gal (379 L) are required to extend through only one valve.

PG-58.3.7 The miscellaneous piping shall include the piping for such items as drains, vents, surface-blow-off, steam and water piping for water columns, gage glasses and pressure gages, and the recirculation return line for a high-temperature water boiler. When a drain is not intended for blowoff purposes (when the boiler is under pressure) a single valve is acceptable, otherwise two valves in series are required except as permitted by PG-58.3.6.

PG-58.3.8 Welded piping in PG-58.3.1, PG-58.3.2, PG-58.3.3, PG-58.3.4, PG-58.3.5, PG-58.3.6, and PG-58.3.7 is also subject to the requirements of PG-104 for proper Code certification.

PG-59 APPLICATION REQUIREMENTS FOR THE BOILER PROPER

PG-59.1 Common to Steam, Feedwater, Blowoff, and Drain Systems

PG-59.1.1 Outlets of a boiler to which piping is to be attached for any purpose, and which piping comes within the Code requirements, shall meet the requirements of PG-39 and shall be:

PG-59.1.1.1 A tapped opening.

PG-59.1.1.2 Bolted flanged joints including those of the Van Stone type.

PG-59.1.1.3 Welding ends of the butt or socket welding type.

PG-59.1.1.4 Piping within the boiler proper may be expanded into grooved holes, seal welded if desired. Blowoff piping of firetube boilers shall be attached by threading into a tapped opening with a threaded fitting or valve at the other end if exposed to products of

combustion, or by PG-59.1.1.1 or PG-59.1.1.2 if not so exposed (see PFT-49).

PG-59.1.2 Steam Mains. Provisions shall be made for the expansion and contraction of steam mains connected to boilers, by providing substantial anchorage at suitable points, so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

PG-59.1.3 Figure PG-59.1 illustrates a typical form of connection for use on boiler shells for passing through piping such as feed, surface blowoff connections, etc., and which permits the pipes' being threaded in solid from both sides in addition to the reinforcing of the opening of the shell. The pipes shall be attached as provided in PG-59.1.1.

In these and other types of boilers where both internal and external pipes making a continuous passage are employed, the boiler bushing or its equivalent shall be used.

PG-59.2 Requirements for Feedwater Connections. The feedwater shall be introduced into a boiler in such a manner that the water will not be discharged directly against surfaces exposed to gases of high temperature or to direct radiation from the fire. For pressures of 400 psi or over, the feedwater inlet through the drum shall be fitted with shields, sleeves, or other suitable means to reduce the effects of temperature differentials in the shell or head. Feedwater, other than condensate returns as provided for in PG-59.3.6, shall not be introduced through the blowoff.

PG-59.3 Requirements for Blowoffs

PG-59.3.1 A blowoff as required herein is defined as a pipe connection provided with valves located in the external piping through which the water in the boiler may be blown out under pressure, excepting drains such as are used on water columns, gage glasses, or piping to feedwater regulators, etc., used for the purpose of determining the operating condition of such equipment. Piping connections used primarily for continuous operation, such as deconcentrators on continuous blowdown systems, are not classed as blowoffs but the pipe connections and all fittings up to and including the first shutoff valve shall be equal at least to the pressure requirements for the lowest set pressure of any safety valve on the boiler drum and with the corresponding saturated-steam temperature.

PG-59.3.2 A surface blowoff connection shall not exceed NPS 2½ (DN 65), and the internal pipe and the terminal connection for the external pipe, when

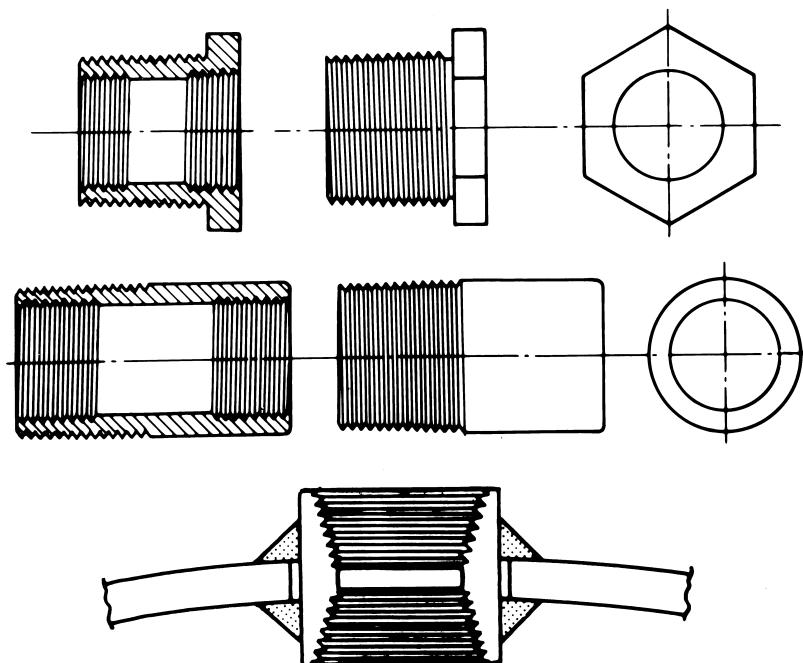


FIG. PG-59.1 TYPICAL BOILER BUSHINGS

used, shall form a continuous passage, but with clearance between their ends and arranged so that the removal of either will not disturb the other. A properly designed steel bushing, similar to or the equivalent of those shown in Fig. PG-59.1, or a flanged connection shall be used.

PG-59.3.3 Each boiler except forced-flow steam generators with no fixed steam and waterline and high-temperature water boilers shall have a bottom blowoff outlet in direct connection with the lowest water space practicable for external piping conforming to PG-58.3.6.

PG-59.3.4 All waterwalls and water screens that do not drain back into the boiler, and all integral economizers, shall be equipped with outlet connections for a blowoff or drain line and conform to the requirements of PG-58.3.6 or PG-58.3.7.

PG-59.3.5 Except as permitted for miniature boilers in Part PMB, the minimum size of blowoff connections shall be NPS 1 (DN 25), and the maximum size shall be NPS 2½ (DN 65), except that for boilers with 100 sq ft (9.3 m²) of heating surface or less, the minimum size of blowoff connections may be NPS ¾ (DN 20).

PG-59.3.6 Condensate return connections of the same size or larger than the size herein specified may be used, and the blowoff may be connected to them.

In such case the blowoff shall be so located that the connection may be completely drained.

PG-59.3.7 A bottom blowoff pipe when exposed to direct furnace heat shall be protected by firebrick or other heat resisting material which is so arranged that the pipe may be inspected.

PG-59.3.8 An opening in the boiler setting for a blowoff pipe shall be arranged to provide free expansion and contraction.

PG-59.4 Requirements for Drains

PG-59.4.1 Ample drain connections shall be provided where required to permit complete drainage of all piping, superheaters, waterwalls, water screens, integral economizers, high-temperature water boilers, and all other boiler components in which water may collect. Piping shall conform to the requirements of PG-58.3.6 or PG-58.3.7.

PG-59.4.1.1 Each superheater shall be equipped with at least one drain connection so located as to most effectively provide for the proper operation of the apparatus.

PG-59.4.1.2 Each high-temperature water boiler shall have a bottom drain connection of at least NPS 1 (DN 25) in direct connection with the lowest water

space practical for external piping conforming to PG-58.3.7.

PG-59.5 Requirements for Valves and Fittings.

The following requirements apply to the use of valves and fittings in the boiler proper.

PG-59.5.1 Steam Stop Valves

PG-59.5.1.1 If a shutoff valve is used between the boiler and its superheater, the safety valve capacity on the boiler shall comply with the requirements of PG-67.2 and PG-70, except as provided for in PG-59.5.1.2, no credit being taken for the safety valve on the superheater, and the superheater must be equipped with safety valve capacity as required by PG-68. A stop valve is not required at the inlet or the outlet of a reheater or separately fired superheater.

PG-59.5.1.2 When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steam and waterline, the safety valves shall satisfy the requirements of PG-67.4.4.

DESIGN AND APPLICATION

PG-60 REQUIREMENTS FOR MISCELLANEOUS PIPE, VALVES, AND FITTINGS

Piping referred to in this paragraph shall be designed in accordance with the applicable requirements of ASME B31.1.

PG-60.1 Water Level Indicators

PG-60.1.1 Boiler with an MAWP of 400 psi (2 800 kPa) or less and electric boilers of the electrode type, require at least one gage glass. Except for electric boilers of the electrode type, boilers with an MAWP over 400 psi (2 800 kPa) require at least two gage glasses. Forced flow steam generators with no fixed steam and waterline, and high-temperature water boilers of the forced circulation type, do not require a gage glass.

When two gage glasses are required, one of the gage glasses may be replaced by two independent remote level indicators. When both remote level indicators are operating reliably, the remaining gage glass may be shut off, but shall be maintained in serviceable condition. When fitted with two gage glasses, both gage glasses may be connected to a single water column or directly to the drum.

At least one gage glass shall be readily visible to the operator in the area where immediate control actions

are initiated. Alternately, two dependable indirect indications shall be provided, either by transmission of the gage glass image or by remote level indicators. A gage glass image transmitted to the operator's working area by means of a fiber optic cable, with no electrical modification of the optic signal, is considered to provide direct reading of the gage glass water level.

The lowest visible part of the water gage glass shall be at least 2 in. (51 mm) above the lowest permissible water level, as determined by the boiler Manufacturer. When remote level indication is provided for the operator in lieu of the gage glass, the same minimum level reference shall be clearly marked.

Tubular or transparent gages that rely on observing the steam-water interface and consist of multiple sections, shall have a minimum of 1 in. (25 mm) overlap of the visible portions. Segmented gages, such as ported gages or end-connected strip gages, shall be equipped to afford obvious visual discrimination between the appearance of water or vapor in the individual sections.

PG-60.1.4 Boilers of the horizontal firetube type shall be so set that when the water is at the lowest reading in the water gage glass there shall be at least 3 in. (76 mm) of water over the highest point of the tubes, flues, or crown sheets.

PG-60.1.5 Boilers of locomotives shall have at least one water glass provided with top and bottom shutoff cocks and lamp.

The lowest reading of water glass shall not be less than 2 in. (51 mm) above the highest point of crown sheet on boilers 36 in. (914 mm) in diameter and under, nor less than 3 in. (76 mm) for boilers over 36 in. (914 mm) in diameter. These are minimum dimensions, and on large locomotives and those operating on steep grades, the height should be increased, if necessary, to compensate for change of water level on descending grades.

The bottom mounting for water glass and for water column if used must extend not less than 1½ in. (38 mm) inside the boiler and beyond any obstacle immediately above it, and the passage therein must be straight and horizontal.

Tubular water glasses must be equipped with a protecting shield.

PG-60.1.6 All connections on the gage glass shall be not less than NPS ½ (DN 15). Each water gage glass shall be fitted with a drain cock or valve having an unrestricted drain opening of not less than ¼ (6 mm) in. diameter to facilitate cleaning. When the boiler operating pressure exceeds 100 psi (690 kPa) the glass

shall be furnished with a connection to install a valved drain to the ash pit or other safe discharge point.

Each water gage glass shall be equipped with a top and a bottom shutoff valve of such through-flow construction as to prevent stoppage by deposits of sediments. If the lowest valve is more than 7 ft (2.1 m) above the floor or platform from which it is operated, the operating mechanism shall indicate by its position whether the valve is open or closed. The pressure-temperature rating shall be at least equal to that of the lowest set pressure of any safety valve on the boiler drum and the corresponding saturated-steam temperature.

Straight-run globe valves shall not be used on such connections.

Automatic shutoff valves, if permitted to be used, shall conform to the requirements given in A-18.

PG-60.2 Water Columns

PG-60.2.1 The water column shall be so mounted that it will maintain its correct position relative to the normal waterline under operating conditions.

PG-60.2.3 The water column shall be fitted with a connection for a drain cock or drain valve to install a pipe of at least NPS $\frac{3}{4}$ (DN 20) to the ash pit or other safe point of discharge.

PG-60.2.4 The design and material of a water column shall comply with the requirements of PG-42. Water column made of cast iron in accordance with SA-278 may be used for maximum boiler pressures not exceeding 250 psi (1 720 kPa). Water columns made of ductile iron in accordance with SA-395 may be used for maximum boiler pressures not exceeding 350 psi (2 410 kPa). For higher pressures, steel construction shall be used.

PG-60.3 Connections

PG-60.3.1 Gage glasses that are required by PG-60.1 shall be connected directly to the shell or drum of the boiler or to an intervening water column.

PG-60.3.2 The lower edge of the steam connection to a water column or gage glass in the boiler shall not be below the highest visible water level in the water gage glass. There shall be no sag or offset in the piping which will permit the accumulation of water.

PG-60.3.3 The upper edge of the water connection to a water column or gage glass and the boiler shall not be above the lowest visible water level in the gage glass. No part of this pipe connection shall be above the point of connection at the water column.

PG-60.3.4 Connections from the boiler to the water column shall be at least NPS 1 (DN 25). Connections for gage glasses connected directly to the boiler shall be at least NPS $\frac{1}{2}$ (DN 15). Connections from the boiler to the remote level indicator shall be at least NPS $\frac{3}{4}$ (DN 20) to and including the isolation valve and from there to the remote level indicator at least $\frac{1}{2}$ in. (13 mm) O.D. tubing. These connections shall be completely independent of other connections for any function other than water level indication.

PG-60.3.5 For pressures of 400 psi (2 800 kPa) or over, lower connections to drums for water columns and remote level indicators shall be provided with shields, sleeves, or other suitable means to reduce the effect of temperature differentials in the shells or heads.

PG-60.3.6 The steam and water connections to a water column or a water gage glass shall be such that they are readily accessible for internal inspection and cleaning. Some acceptable methods of meeting this requirement are by providing a cross or fitting with a back outlet at each right-angle turn to permit inspection and cleaning in both directions, or by using pipe bends or fittings of a type that does not leave an internal shoulder or pocket in the pipe connection and with a radius of curvature that will permit the passage of a rotary cleaner. Screwed plug closures using threaded connections as allowed by PG-39.5.3 are acceptable means of access for this inspection and cleaning. For boilers with all drum safety valves set at or above 400 psig (2 800 kPa), socket-welded plugs may be used for this purpose in lieu of screwed plugs. If the water connection to the water column has a rising bend or pocket that cannot be drained by means of the water-column drain, an additional drain shall be placed on this connection in order that it may be blown off to clear any sediment from the pipe.

PG-60.3.7 Shutoff valves shall not be used in the pipe connections between a boiler and a water column or between a boiler and the shutoff valves required for the gage glass (PG-60.1.6), unless they are either outside-screw-and-yoke or lever-lifting type gate valves or stopcocks with lever permanently fastened thereto and marked in line with their passage, or of such other through-flow construction as to prevent stoppage by deposits of sediment, and to indicate by the position of the operating mechanism whether they are in open or closed position; and such valves or cocks shall be locked or sealed open. Where stopcocks are used they shall be of a type with the plug held in place by a guard or gland.

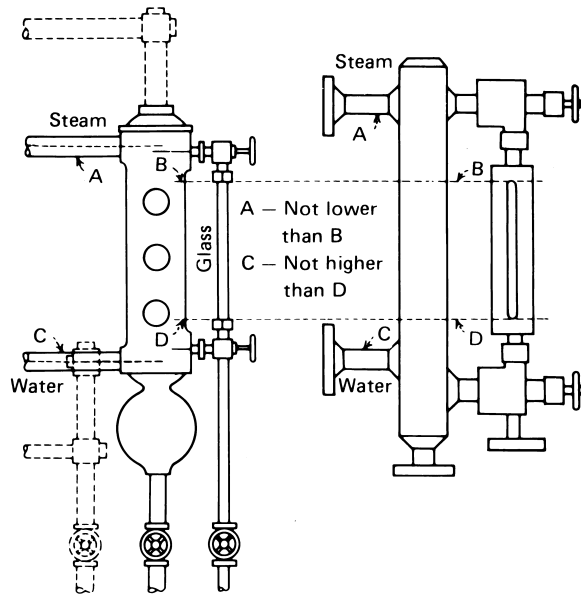


FIG. PG-60 TYPICAL ARRANGEMENT OF STEAM AND WATER CONNECTIONS FOR A WATER COLUMN

The lock or seal open requirement may be waived if the following additional conditions are met.

- (1) MAWP shall not exceed 250 psig (1 720 kPa).
- (2) The boiler shall not be hand fired or fired with solid fuel not in suspension.
- (3) Interlocks between the valve and the burner control system shall stop fuel supply and prevent firing whenever the valve between the drum and the water column is not in the fully open position.
- (4) Provision shall be made in the valve body to permit cleaning and rodding of horizontal and vertical legs of attached pipe when the boiler is out of service.
- (5) The minimum valve size shall be NPS 1 (DN 25).
- (6) The valve shall indicate by its position whether it is open or closed.

PG-60.3.8 No outlet connections, except for control devices (such as damper regulators and feedwater regulators), drains, steam gages, or apparatus of such form as does not permit the escape of an appreciable amount of steam or water therefrom shall be placed on the piping connecting a water column or gage glass to a boiler.

PG-60.3.9 An acceptable arrangement is shown in Fig. PG-60.

PG-60.4 Gage Cocks. Not required.

PG-60.5 Water Fronts. Each boiler fitted with a water jacketed boiler-furnace mouth protector, or similar appliance having valves on the pipes connecting them to the boiler shall have these valves locked or sealed open. Such valves, when used, shall be of the straightway type.

PG-60.6 Pressure Gages

PG-60.6.1 Each boiler shall have a pressure gage so located that it is easily readable. The pressure gage shall be installed so that it shall at all times indicate the pressure in the boiler. Each steam boiler shall have the pressure gage connected to the steam space or to the water column or its steam connection. A valve or cock shall be placed in the gage connection adjacent to the gage. An additional valve or cock may be located near the boiler providing it is locked or sealed in the open position. No other shutoff valves shall be located between the gage and the boiler. The pipe connection shall be of ample size and arranged so that it may be cleared by blowing out. For a steam boiler the gage or connection shall contain a syphon or equivalent device that will develop and maintain a water seal that will prevent steam from entering the gage tube. Pressure gage connections shall be suitable for the maximum allowable working pressure and temperature, but if the temperature exceeds 406°F (208°C), brass or copper pipe or tubing shall not be used. The connections to the boiler, except the syphon, if used, shall not be less than NPS $\frac{1}{4}$ (DN 8) but where steel or wrought iron pipe or tubing is used, they shall not be less than $\frac{1}{2}$ in. (13 mm) inside diameter. The minimum size of a syphon, if used, shall be $\frac{1}{4}$ in. (6 mm) inside diameter. The dial of the pressure gage shall be graduated to approximately double the pressure at which the safety valve is set, but in no case to less than $1\frac{1}{2}$ times this pressure.

PG-60.6.2 Each forced-flow steam generator with no fixed steam and waterline shall be equipped with pressure gages or other pressure measuring devices located as follows:

PG-60.6.2.1 At the boiler or superheater outlet (following the last section which involves absorption of heat), and

PG-60.6.2.2 At the boiler or economizer inlet (preceding any section that involves absorption of heat), and

PG-60.6.2.3 Upstream of any shutoff valve that

may be used between any two sections of the heat absorbing surface.

PG-60.6.3 Each boiler shall be provided with a valve connection at least NPS $\frac{1}{4}$ (DN 8) for the exclusive purpose of attaching a test gage when the boiler is in service, so that the accuracy of the boiler pressure gage can be ascertained.

PG-60.6.4 Each high-temperature water boiler shall have a temperature gage so located and connected that it shall be easily readable. The temperature gage shall be installed so that it at all times indicates the temperature in degrees Fahrenheit of the water in the boiler, at or near the outlet connection.

PG-61 FEEDWATER SUPPLY

PG-61.1 Except as provided for in PG-61.2 and PG-61.4, boilers having more than 500 sq ft (47 m²) of water-heating surface shall have at least two means of feeding water. Except as provided for in PG-61.3, PG-61.4, and PG-61.5, each source of feeding shall be capable of supplying water to the boiler at a pressure of 3% higher than the highest setting of any safety valve on the boiler. For boilers that are fired with solid fuel not in suspension, and for boilers whose setting or heat source can continue to supply sufficient heat to cause damage to the boiler if the feed supply is interrupted, one such means of feeding shall not be susceptible to the same interruption as the other, and each shall provide sufficient water to prevent damage to the boiler.

01 PG-61.2 Except as provided for in PG-61.1, a boiler fired by gaseous, liquid, or solid fuel in suspension, or heated by combustion turbine engine exhaust, may be equipped with a single means of feeding water provided means are furnished for the shutting off of its heat input prior to the water level reaching the lowest permissible level established by PG-60.

PG-61.3 For boilers having a water-heating surface of not more than 100 sq ft (9.3 m²) the feed connection to the boiler shall not be smaller than NPS $\frac{1}{2}$ (DN 15). For boilers having a water-heating surface more than 100 sq ft (9.3 m²) the feed connection to the boiler shall not be less than NPS $\frac{3}{4}$ (DN 20).

PG-61.4 High-temperature water boilers shall be provided with means of adding water to the boiler or system while under pressure.

PG-61.5 A forced-flow steam generator with no fixed steam and waterline shall be provided with a source

of feeding capable of supplying water to the boiler at a pressure not less than the expected maximum sustained pressure at the boiler inlet, as determined by the boiler Manufacturer, corresponding to operation at maximum designed steaming capacity with maximum allowable working pressure at the superheater outlet.

SAFETY VALVES AND SAFETY RELIEF VALVES¹⁸

PG-67 BOILER SAFETY VALVE REQUIREMENTS

PG-67.1 Each boiler shall have at least one safety valve or safety relief valve and if it has more than 500 sq ft (47 m²) of bare tube water-heating surface, or if an electric boiler has a power input more than 1,100 kW, it shall have two or more safety valves or safety relief valves. For a boiler with combined bare tube and extended water-heating surface exceeding 500 sq ft (47 m²), two or more safety valves or safety relief valves are required only if the design steam generating capacity of the boiler exceeds 4,000 lb/hr (1 800 kg/hr). Organic fluid vaporizer generators require special consideration as given in Part PVG.

PG-67.2 The safety valve or safety relief valve capacity for each boiler (except as noted in PG-67.4) shall be such that the safety valve, or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set and in no case to more than 6% above the maximum allowable working pressure.

PG-67.2.1 The minimum required relieving capacity of the safety valves or safety relief valves for all types of boilers shall not be less than the maximum designed steaming capacity as determined by the Manufacturer and shall be based on the capacity of all the fuel burning equipment as limited by other boiler functions.

¹⁸ Safety Valve: An automatic pressure relieving device actuated by the static pressure upstream of the valve and characterized by full-opening pop action. It is used for gas or vapor service.

Relief Valve: An automatic pressure relieving device actuated by the static pressure upstream of the valve which opens further with the increase in pressure over the opening pressure. It is used primarily for liquid service.

Safety Relief Valve: An automatic pressure-actuated relieving device suitable for use either as a safety valve or relief valve, depending on application.

Unless otherwise defined, the definitions relating to pressure relief devices in Appendix I of ASME PTC 25-1994, Pressure Relief Devices, shall apply.

PG-67.2.2 The minimum required relieving capacity for a waste heat boiler shall be determined by the Manufacturer. When auxiliary firing is to be used in combination with waste heat recovery, the maximum output as determined by the boiler Manufacturer shall include the effect of such firing in the total required capacity. When auxiliary firing is to be used in place of waste heat recovery, the minimum required relieving capacity shall be based on auxiliary firing or waste heat recovery, whichever is higher.

PG-67.2.3 The minimum required relieving capacity for electric boilers shall be in accordance with PEB-15.

PG-67.2.4 The minimum required relieving capacity in lb/hr for a high-temperature water boiler shall be determined by dividing the maximum output in Btu/hr at the boiler nozzle, produced by the highest heating value fuel for which the boiler is designed, by 1,000.

PG-67.2.5 The minimum required relieving capacity for organic fluid vaporizers shall be in accordance with PVG-12.

PG-67.2.6 Any economizer that may be shut off from the boiler, thereby permitting the economizer to become a fired pressure vessel, shall have one or more safety relief valves with a total discharge capacity, in lbs/hr, calculated from the maximum expected heat absorption in Btu/hr, as determined by the Manufacturer, divided by 1,000. This absorption shall be stated in the stamping (PG-106.4).

PG-67.3 One or more safety valves on the boiler proper shall be set at or below the maximum allowable working pressure (except as noted in PG-67.4). If additional valves are used the highest pressure setting shall not exceed the maximum allowable working pressure by more than 3%. The complete range of pressure settings of all the saturated-steam safety valves on a boiler shall not exceed 10% of the highest pressure to which any valve is set. Pressure setting of safety relief valves on high-temperature water boilers¹⁹ may exceed this 10% range.

PG-67.4 For a forced-flow steam generator with no fixed steam and waterline, equipped with automatic controls and protective interlocks responsive to steam

pressure, safety valves may be provided in accordance with the above paragraphs or the following protection against overpressure shall be provided:

PG-67.4.1 One or more power-actuated pressure relieving valves²⁰ shall be provided in direct communication with the boiler when the boiler is under pressure and shall receive a control impulse to open when the maximum allowable working pressure at the superheater outlet, as shown in the master stamping (PG-106.3), is exceeded. The total combined relieving capacity of the power-actuated relieving valves shall be not less than 10% of the maximum design steaming capacity of the boiler under any operating condition as determined by the Manufacturer. The valve or valves shall be located in the pressure part system where they will relieve the overpressure.

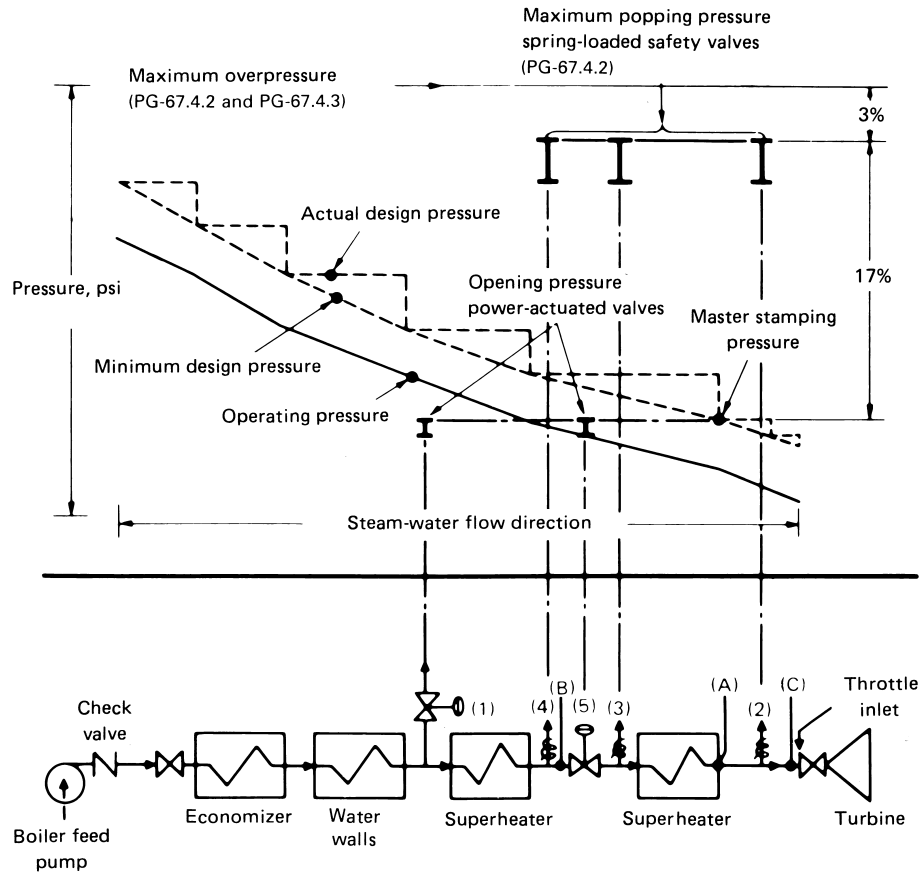
An isolating stop valve of the outside-screw-and-yoke or ball type may be installed between the power-actuated pressure relieving valve and the boiler to permit repairs provided an alternate power-actuated pressure relieving valve of the same capacity is so installed as to be in direct communication with the boiler in accordance with the requirements of this paragraph.

The isolating stop valve port area shall at least equal the area of the inlet of the power-actuated pressure relieving valve. If the isolating stop valve is of the ball type, the valve shall include a means to clearly identify whether the valve is in the open or closed position. If the isolating stop valve is power actuated (air, motor, hydraulic, etc.), a manual override mechanism shall be provided.

Power-actuated pressure relieving valves discharging to intermediate pressure and incorporated into bypass and/or startup circuits by the boiler Manufacturer need not be capacity certified. Instead, they shall be marked by the valve manufacturer with a capacity rating at a set of specified inlet pressure and temperature conditions. Power-actuated pressure relieving valves discharging directly to atmosphere shall be capacity certified. This capacity certification shall be conducted in accordance with the provisions of PG-69.3. The valves shall be marked in accordance with the provisions of PG-69.4 and PG-69.5.

¹⁹ Safety relief valves in hot water service are more susceptible to damage and subsequent leakage, than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and the safety relief valve setting for high-temperature water boilers be selected substantially higher than the desired operating pressure so as to minimize the times the safety relief valve must lift.

²⁰ The power-actuated pressure relieving valve is one whose movements to open or close are fully controlled by a source of power (electricity, air, steam, or hydraulic). The valve may discharge to atmosphere or to a container at lower pressure. The discharge capacity may be affected by the downstream conditions, and such effects shall be taken into account. If the power-actuated pressure relieving valves are also positioned in response to other control signals, the control impulse to prevent overpressure shall be responsive only to pressure and shall override any other control function.

**Pressure**

- (A) = master stamping (PG-106.3)
 (B) = component design at inlet to stop valve (5) (PG-67.4.4.1)
 (C) = turbine throttle inlet (ANSI/ASME B31.1, paragraph 122.1.2, A.4)

Pressure Relief Valves

- (1) = power actuated (PG-67.4.1)
 (2), (3), and (4) = spring loaded safety (PG-67.4.2)
 (5) = superheater stop (PG-67.4.4)

Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)

- (1) = 10 – 30% (PG-67.4.1)
 (2) = minimum of one valve (PG-68.1)
 (2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
 (2) + (3) + (4) = 100% – (1) (PG-67.4.2)

Relief Valve Opening Pressure (maximum)

- (1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
 (2), (3), and (4) = (A) + 17% (PG-67.4.2)
 (5) = (A) (PG-67.4.1)

Alternate Requirements for Safety Valves**Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)**

- (1) = 10 – 30% (PG-67.4.1)
 (2) = one valve minimum (PG-68.1)
 (2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
 (4) = 10% total with minimum of 2 valves when there is a stop valve (5) (PG-67.5.3.3)
 (2) + (4) = 10% with minimum of 2 valves when there is no stop valve (5) (PG-67.4.3.3)

Relief Valve Opening Pressure (maximum)

- (1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
 (2), (3), and (4) = (A) + 20% (PG-67.4.3.3)
 (5) = (A) (PG-67.4.1)

Automatic Pressure Controls (PG-67.4.3)

- (a) at (C) for normal operation under load (PG-67.4.3.2.1)
 (b) at (A) + 10% to override control (a) (PG-67.4.3.2.2)
 (c) at (A) + 20% to shut off flow of fuel and feedwater (PG-67.4.3.2.3)
 (d) safety valves at (4) to shut off flow of fuel and feedwater by "fail-safe" power circuit (PG-67.4.3.4)

FIG. PG-67.4 REQUIREMENTS FOR PRESSURE RELIEF FORCED-FLOW STEAM GENERATOR

PG-67.4.2 Spring-loaded safety valves shall be provided, having a total combined relieving capacity, including that of the power-actuated pressure relieving capacity installed under PG-67.4.1, of not less than 100% of the maximum designed steaming capacity of the boiler, as determined by the Manufacturer, except the alternate provisions of PG-67.4.3 are satisfied. In this total, no credit in excess of 30% of the total required relieving capacity shall be allowed for the power-actuated pressure relieving valves actually installed. Any or all of the spring-loaded safety valves may be set above the maximum allowable working pressure of the parts to which they are connected, but the set pressures shall be such that when all of these valves (together with the power-actuated pressure relieving valves) are in operation the pressure will not rise more than 20% above the maximum allowable working pressure of any part of the boiler, except for the steam piping between the boiler and the prime mover.

PG-67.4.3 The total installed capacity of spring-loaded safety valves may be less than the requirements of PG-67.4.2 provided all of the following conditions are met.

PG-67.4.3.1 The boiler shall be of no less steaming capacity than 1,000,000 lb/hr (450 000 kg/hr) and installed in a unit system for power generation (i.e., a single boiler supplying a single turbine-generator unit).

PG-67.4.3.2 The boiler shall be provided with automatic devices, responsive to variations in steam pressure, which include no less than all the following:

PG-67.4.3.2.1 A control capable of maintaining steam pressure at the desired operating level and of modulating firing rates and feedwater flow in proportion to a variable steam output; and

PG-67.4.3.2.2 A control that overrides PG-67.4.3.2.1 by reducing the fuel rate and feedwater flow when the steam pressure exceeds the maximum allowable working pressure as shown in the master stamping (PG-106.3) by 10%; and

PG-67.4.3.2.3 A direct-acting overpressure-trip-actuating mechanism, using an independent pressure sensing device, that will stop the flow of fuel and feedwater to the boiler, at a pressure higher than the set pressure of PG-67.4.3.2.2, but less than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

PG-67.4.3.3 There shall be not less than two spring-loaded safety valves and the total rated relieving

capacity of the spring-loaded safety valves shall be not less than 10% of the maximum designed steaming capacity of the boiler as determined by the Manufacturer. These spring-loaded safety valves may be set above the maximum allowable working pressure of the parts to which they are connected but shall be set such that the valves will lift at a pressure no higher than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

PG-67.4.3.4 At least two of these spring-loaded safety valves shall be equipped with a device that directly transmits the valve stem lift action to controls that will stop the flow of fuel and feedwater to the boiler. The control circuitry to accomplish this shall be arranged in a "fail-safe" manner (see Note).

NOTE: "Fail-safe" shall mean a circuitry arranged as either of the following:

(1) *Energize to trip:* There shall be at least two separate and independent trip circuits served by two power sources, to initiate and perform the trip action. One power source shall be a continuously charged dc battery. The second source shall be an ac-to-dc converter connected to the dc system to charge the battery and capable of performing the trip action. The trip circuits shall be continuously monitored for availability.

It is not mandatory to duplicate the mechanism that actually stops the flow of fuel and feedwater.

(2) *De-energize to trip:* If the circuits are arranged in such a way that a continuous supply of power is required to keep the circuits closed and operating and such that any interruption of power supply will actuate the trip mechanism, then a single trip circuit and single power supply will be enough to meet the requirements of this subparagraph.

PG-67.4.3.5 The power supply for all controls and devices required by PG-67.4.3 shall include at least one source contained within the same plant as the boiler and which is arranged to actuate the controls and devices continuously in the event of failure or interruption of any other power sources.

PG-67.4.4 When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steam and waterline:

PG-67.4.4.1 The power-actuated pressure relieving valve(s) required by PG-67.4.1 shall also receive a control impulse to open when the maximum allowable working pressure of the component, having the lowest pressure level upstream to the stop valve, is exceeded; and

PG-67.4.4.2 The spring-loaded safety valves shall be located to provide the pressure protection requirements in PG-67.4.2 or PG-67.4.3.

PG-67.4.5 A reliable pressure-recording device shall always be in service and records kept to provide evidence of conformity to the above requirements.

- 01 PG-67.5** All safety valves or safety relief valves shall be so constructed that the failure of any part cannot obstruct the free and full discharge of steam and water from the valve. Safety valves shall be of the direct spring-loaded pop type, with seat inclined at any angle between 45 deg and 90 deg, inclusive, to the center line of the spindle. The coefficient of discharge of safety valves shall be determined by actual steam flow measurements at a pressure not more than 3% above the pressure at which the valve is set to blow and when adjusted for blowdown in accordance with PG-69.1.4. The valves shall be credited with capacities as determined by the provisions of PG-69.2.

Safety valves or safety relief valves may be used that give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve, provided the movement of the steam safety valve is such as not to induce lifting of water in the boiler.

Deadweight or weighted lever safety valves or safety relief valves shall not be used.

For high-temperature water boilers safety relief valves shall be used. Such valves shall have a closed bonnet. For purposes of selection the capacity rating of such safety relief valves shall be expressed in terms of actual steam flow determined on the same basis as for safety valves. In addition the safety relief valves shall be capable of satisfactory operation when relieving water at the saturation temperature corresponding to the pressure at which the valve is set to blow.

PG-67.6 A safety valve or safety relief valve over NPS 3 (DN 80), used for pressures greater than 15 psig (103 kPa), shall have a flanged inlet connection or a weld-end inlet connection. The dimensions of flanges subjected to boiler pressure shall conform to the applicable ASME Standards as given in PG-42. The facing shall be similar to those illustrated in the Standard.

PG-67.7 Safety valves or safety relief valves may have bronze parts complying with either SB-61 or SB-62, provided the maximum allowable stresses and temperatures do not exceed the values given in Table 1B of Section II, Part D, and shall be marked to indicate the class of material used. Such valves shall not be used on superheaters delivering steam at a temperature over 450°F (232°C) and 306°F (152°C) respectively, and shall not be used for high-temperature water boilers.

PG-68 SUPERHEATER AND REHEATER SAFETY VALVE REQUIREMENTS

PG-68.1 Except as permitted in PG-58.3.1, every attached superheater shall have one or more safety valves in the steam flow path between the superheater outlet and the first stop valve. The location shall be suitable for the service intended and shall provide the overpressure protection required. The pressure drop upstream of each safety valve shall be considered in the determination of set pressure and relieving capacity of that valve. If the superheater outlet header has a full, free steam passage from end to end and is so constructed that steam is supplied to it at practically equal intervals throughout its length so that there is a uniform flow of steam through the superheater tubes and the header, the safety valve, or valves, may be located anywhere in the length of the header.

PG-68.2 The discharge capacity of the safety valve, or valves, on an attached superheater may be included in determining the number and size of the safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler, and provided the discharge capacity of the safety valve, or valves, on the boiler, as distinct from the superheater is at least 75% of the aggregate valve capacity required.

PG-68.3 Every separately fired superheater which may be shut off from the boiler and permit the superheater to become a fired pressure vessel shall have one or more safety valves having a discharge capacity equal to 6 lb of steam per hour per square foot of superheater surface measured on the side exposed to the hot gases. As an alternative the Manufacturer may also calculate the minimum safety valve discharge capacity in lbs. of steam per hour from the maximum expected heat absorption (as determined by the Manufacturer) in Btu/hr, divided by 1,000. In the case of electrically heated superheaters, the safety valve capacity shall be based upon $3\frac{1}{2}$ lb/hr/kW input. The number of safety valves installed shall be such that the total capacity is at least equal to that required.

PG-68.4 Every reheater shall have one or more safety valves, such that the total relieving capacity is at least equal to the maximum steam flow for which the heater is designed. The capacity of the reheater safety valves shall not be included in the required relieving capacity for the boiler and superheater.

One or more valves with a combined relieving capacity not less than 15% of the required total shall be located along the steam flow path between the reheater outlet and the first stop valve. The pressure drop

upstream of the valves on the outlet side of the reheater shall be considered in determining their set pressure.

PG-68.5 A soot blower connection may be attached to the same outlet from the superheater or reheater that is used for the safety valve connection.

PG-68.6 Every safety valve used on a superheater or reheater discharging superheated steam at a temperature over 450°F (232°C) shall have a casing, including the base, body, and bonnet and spindle, of steel, steel alloy, or equivalent heat-resisting material.

The valve shall have a flanged inlet connection, or a weld-end inlet connection. It shall have the seat and disk of suitable heat erosive and corrosive resisting material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

PG-69 CERTIFICATION OF CAPACITY OF SAFETY AND SAFETY RELIEF VALVES

PG-69.1 Before the Code symbol is applied to any safety or safety relief valve, the valve manufacturer shall have the relieving capacity of his valves certified in accordance with the provisions of this paragraph.

PG-69.1.1 Capacity certification tests shall be conducted using dry saturated steam. The limits for test purposes shall be 98% minimum quality and 20°F (11°C) maximum superheat. Correction from within these limits may be made to the dry saturated condition.

PG-69.1.2 Tests shall be conducted at a place that meets the requirements of Appendix A-312.

PG-69.1.3 Capacity test data reports for each valve design and size, signed by the manufacturer and Authorized Observer witnessing the tests, together with drawings showing the valve construction, shall be submitted to the ASME designee for review and acceptance.²¹

PG-69.1.4 Capacity certification tests shall be conducted at a pressure that does not exceed the set pressure by 3% or 2 psi (14 kPa), whichever is greater. Safety and safety relief valves shall be adjusted so that the blowdown does not exceed 4% of the set pressure. For valves set at or below 100 psi (690 kPa), the blowdown shall be adjusted so as not to exceed 4 psi

(28 kPa). Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers shall be adjusted so that the blowdown does not exceed 10% of the set pressure. The reseating pressure shall be noted and recorded.

PG-69.2 Relieving capacities shall be determined using one of the following methods.

PG-69.2.1 Three Valve Method. A capacity certification test is required on a set of three valves for each combination of size, design, and pressure setting. The capacity of each valve of the set shall fall within a range of ±5% of the average capacity. If one of the three valves tested falls outside this range, it shall be replaced by two valves, and a new average shall be calculated based on all four valves, excluding the replaced valve. Failure of any of the four capacities to fall within a range of ±5% of the new average shall be cause to refuse certification of that particular valve design.

The rated relieving capacity for each combination of design, size, and test pressure shall be 90% of the average capacity.

PG-69.2.2 Slope Method. If a Manufacturer wishes to apply the Code Symbol to a design of pressure relief valves, four valves of each combination of pipe size and orifice size shall be tested. These four valves shall be set at pressures which cover the approximate range of pressures for which the valve will be used or covering the range available at the certified test facility that shall conduct the tests. The capacities based on these four tests shall be as follows:

(a) The slope W/P of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

$$\text{slope} = \frac{W}{P} = \frac{\text{measured capacity}}{\text{absolute flow rating pressure, psia}}$$

All values derived from the testing must fall within ±5% of the average value:

$$\text{minimum slope} = 0.95 \times \text{average slope}$$

$$\text{maximum slope} = 1.05 \times \text{average slope}$$

If the values derived from the testing do not fall between the minimum and maximum slope values, the

²¹ Valve capacities are published in "Pressure Relief Device Certifications." This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Ave., Columbus, OH 43229.

Authorized Observer shall require that additional valves be tested at the rate of two for each valve beyond the maximum and minimum values with a limit of four additional valves.

The relieving capacity to be stamped on the valve shall not exceed 90% of the average slope times the absolute accumulation pressure:

$$\text{rated slope} = 0.90 \times \text{average slope}$$

Customary Units

stamped capacity $\leq$ rated slope $(1.03 \times \text{set pressure}$

+ 14.7) or (set pressure + 2 psi

+ 14.7), whichever is greater

SI Units

stamped capacity $\leq$ rated slope $(1.03 \times \text{set pressure}$

+ 101) or (set pressure + 14 kPa

+ 101), whichever is greater

PG-69.2.3 Coefficient of Discharge Method. A coefficient of discharge for the design, K , may be established for a specific valve design according to the following procedure.

(a) For each design, the safety or safety relief valve manufacturer shall submit for test at least three valves for each of three different sizes (a total of nine valves). Each valve of a given size shall be set at a different pressure, covering the range of pressures for which the valve will be used or the range available at the facility where the tests are conducted.

(b) Tests shall be made on each safety or safety relief valve to determine its lift at capacity, popping, and blowdown pressures, and actual relieving capacity. An individual coefficient, K_D , shall be established for each valve as follows:

$$K_D = \frac{\text{actual flow}}{\text{theoretical flow}} = \text{individual coefficient of discharge}$$

Where actual flow is determined by test and theoretical flow, W_T is calculated by one of the following equations:

For 45 deg seat

Customary Units

$$W_T = 51.5 \times \pi DLP \times 0.707$$

SI Units

$$W_T = 5.25 \times \pi DLP \times 0.707$$

For flat seat

Customary Units

$$W_T = 51.5 \times \pi DLP$$

SI Units

$$W_T = 5.25 \times \pi DLP$$

For nozzle

Customary Units

$$W_T = 51.5 AP$$

SI Units

$$W_T = 5.25 AP$$

where

W_T = theoretical flow, lb/hr (kg/hr)

A = nozzle throat area, sq in. (sq m)

P = $(1.03 \times \text{set pressure} + 14.7)$, psia, or

= (set pressure + 2 + 14.7), psia, whichever is greater

P = $(1.03 \times \text{set pressure} + 101)$, kPa, or

= (set pressure + 14 + 101), kPa, whichever is greater

L = lift pressure at P , in. (mm)

D = seat diameter, in. (mm)

The average of the coefficients K_D of the nine tests required shall be multiplied by 0.90, and this product shall be taken as the coefficient K of that design. All individual coefficients of discharge, K_D , shall fall within a range of $\pm 5\%$ of the average coefficient found. If a valve fails to meet this requirement, the Authorized Observer shall require two additional valves to be tested as replacements for each valve having an individual coefficient, K_D , outside the $\pm 5\%$ range, with a limit of four additional valves. Failure of a coefficient, K_D , to fall within $\pm 5\%$ of the new average value, excluding the replaced valve(s), shall be cause to refuse certification of that particular valve design.

The rated relieving capacity of all sizes and set pressures of a given design, for which K has been

established under the provision of this paragraph, shall be determined by the equation:

$$W \leq W_T \times K$$

where

W = rated relieving capacity, lb/hr

W_T = theoretical flow, defined by the same equation used to determine K_D , lb/hr

K = coefficient of discharge for the design

The coefficient of discharge for the design shall not be greater than 0.878 (the product of 0.9×0.975). The coefficient shall not be applied to valves whose beta ratio (ratio of valve throat to inlet diameter) lies outside the range of 0.15 to 0.75, unless tests have demonstrated that the individual coefficient of discharge, K_D , for valves at the extreme ends of a larger range, is within $\pm 5\%$ of the average coefficient, K_D .

For designs where the lift is used to determine the flow area, all valves shall have the same nominal lift to seat diameter ratio (L/D).

For pressures over 1,500 psig and up to 3,200 psig, the value of W shall be multiplied by the correction factor:

Customary Units

$$\frac{0.1906P - 1,000}{0.2292P - 1,061}$$

SI Units

$$\frac{0.1906P - 6\,895}{0.2292P - 7\,315}$$

PG-69.3 If a manufacturer wishes to apply the Code symbol to a power-actuated pressure relieving valve under PG-67.4.1, one valve of each combination of inlet pipe size and orifice size to be used with that inlet pipe size shall be tested. The valve shall be capacity tested at four different pressures approximately covering the range of the certified test facility on which the tests are conducted. The capacities, as determined by these four tests, shall be plotted against the absolute flow test pressure and a line drawn through these four test points. All points must lie within $\pm 5\%$ in capacity value of the plotted line and must pass through 0-0. From the plotted line, the slope of the line dW/dP shall be determined and a factor of $(0.90/51.45) \times (dW/dP)$ shall be applied to capacity computations in the supercritical region at elevated pressures by means of the isentropic flow equation.

Customary Units

$$W = 1,135.8 \frac{0.90}{51.45} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

SI Units

$$W = 1\,135.8 \frac{0.95}{5.25} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

where

W = capacity, lb of steam/hr (kg/hr)

P = absolute inlet pressure, psia (kPa)

v = inlet specific volume, cu ft/lb (m^3/kg)

dW/dP = rate of change of measured capacity with respect to absolute pressure

NOTE: The constant 1,135.8 is based on a γ factor of 1.30, which is accurate for superheated steam at temperature above approximately 800°F (427°C). In interest of accuracy, other methods of capacity computations must be used at temperatures below 800°F (427°C) at supercritical pressures.

PG-69.4 Power-actuated pressure relieving valves, having capacities certified in accordance with the provision of PG-69.3 and computed in accordance with the formula contained therein, shall be marked as required by PG-110 with the computed capacity, corresponding to 3% above the full load operating pressure and temperature conditions at the valve inlet when the valve is operated by the controller, and they shall also be stamped with the set pressure of the controller. When the valve is marked as required by this paragraph, it shall be the guarantee by the manufacturer that the valve also conforms to the details of construction herein specified.

PG-69.6 When changes are made in the design of a safety or safety relief valve in such a manner as to affect the flow path, lift, or performance characteristics of the valve, new tests in accordance with this Section shall be performed.

PG-70 CAPACITY OF SAFETY VALVES

PG-70.1 Subject to the minimum number required by PG-67.1, the number of safety valves or safety relief valves required shall be determined on the basis of the maximum designed steaming capacity, as determined by the boiler Manufacturer, and the relieving capacity marked on the valves by the manufacturer.

PG-71 MOUNTING

PG-71.1 When two or more safety valves are used on a boiler, they may be mounted either separately or

as twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body casing. Twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body, shall be of approximately equal capacity.

When not more than two valves of different sizes are mounted singly the relieving capacity of the smaller valve shall be not less than 50% of that of the larger valve.

PG-71.2 The safety valve or safety relief valve or valves shall be connected to the boiler independent of any other connection, and attached as close as possible to the boiler or the normal steam flow path, without any unnecessary intervening pipe or fitting. Such intervening pipe or fitting shall be not longer than the face-to-face dimension of the corresponding tee fitting of the same diameter and pressure under the applicable ASME Standard listed in PG-42 and shall also comply with PG-8 and PG-39. Every safety valve or safety relief valve shall be connected so as to stand in an upright position, with spindle vertical. On high-temperature water boilers of the watertube forced-circulation type, the valve shall be located at the boiler outlet.

PG-71.3 The opening or connection between the boiler and the safety valve or safety relief valve shall have at least the area of the valve inlet. No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, nor on the discharge pipe between the safety valve or safety relief valve and the atmosphere. When a discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets, discharging thereto. It shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

All safety valve or safety relief valve discharges shall be so located or piped as to be carried clear from running boards or platforms. Ample provision for gravity drain shall be made in the discharge pipe at or near each safety valve or safety relief valve, and where water of condensation may collect. Each valve shall have an open gravity drain through the casing below the level of the valve seat. For iron- and steel-bodied valves exceeding NPS 2½ (DN 65), the drain hole shall be tapped not less than NPS ¾ (DN 10).

Discharge piping from safety relief valves on high-temperature water boilers shall be provided with adequate provisions for water drainage as well as the steam venting.

The installation of cast iron bodied safety relief valves for high-temperature water boilers is prohibited.

PG-71.4 If a muffler is used on a safety valve or safety relief valve, it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid a possibility of restriction of the steam passages due to deposit. Mufflers shall not be used on high-temperature water boiler safety relief valves.

When a safety valve or safety relief valve is exposed to outdoor elements which may affect operation of the valve, it is permissible to shield the valve with a satisfactory cover. The shield or cover shall be properly vented and arranged to permit servicing and normal operation of the valve.

PG-71.5 When a boiler is fitted with two or more safety valves or safety relief valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves or safety relief valves with which it connects and shall also meet the requirements of PG-71.3.

PG-71.6 Safety valves may be attached to drums or headers by welding provided the welding is done in accordance with Code requirements.

PG-71.7 Every boiler shall have proper outlet connections for the required safety valve, or safety relief valve, or valves, independent of any other outside steam connection, the area of opening to be at least equal to the aggregate areas of inlet connections of all of the safety valves or safety relief valves to be attached thereto. An internal collecting pipe, splash plate, or pan may be used, provided the total area for inlet of steam thereto is not less than twice the aggregate areas of the inlet connections of the attached safety valves. The holes in such collecting pipes shall be at least ¼ in. (6 mm) in diameter and the least dimension in any other form of opening for inlet of steam shall be ¼ in. (6 mm).

Such dimensional limitations to operation for steam need not apply to steam scrubbers or driers provided the net free steam inlet area of the scrubber or drier is at least 10 times the total area of the boiler outlets for the safety valves.

PG-71.8 If safety valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall be not less than required by PG-71.7.

PG-72 OPERATION

PG-72.1 Safety valves shall be designed and constructed to operate without chattering and to attain full lift at a pressure no greater than 3% above their set pressure. After blowing down, all valves set at pressures of 375 psi (2 600 kPa) or greater shall close at a pressure not lower than 96% of their set pressure, except that all drum valves installed on a single boiler may be set to reseal at a pressure not lower than 96% of the set pressure of the lowest set drum valve. All valves set at pressures below 375 psi (2 600 kPa) shall have a blowdown not greater than that specified in the following table, except that all drum valves installed on a single boiler may be set to reseal at a pressure not lower than the resealing pressure of the lowest set drum valve:

Set Pressure, psi (kPa)	Maximum Blowdown
< 67 (462)	4 psi (14 kPa)
≥ 67 (462) and ≤ 250 (1 720)	6% of set pressure
> 250 (1 720) and < 375 (2 590)	15 psi (103 kPa)

The minimum blowdown for all safety or safety relief valves shall be 2 psi (13.8 kPa) or 2% of the set pressure, whichever is greater.

Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers may be set and adjusted to close after blowing down not more than 10% of the set pressure. The valves for these special uses must be so adjusted and marked by the manufacturer.

PG-72.2 The popping point tolerance plus or minus shall not exceed that specified in the following table:

Set Pressure, psi (kPa)	Tolerance, plus or minus from set pressure
≤ 70 (480)	2 psi (14 kPa)
> 70 (480) and ≤ 300 (2 070)	3% of set pressure
> 300 (2 070) and ≤ 1,000 (6 900)	10 psi (69 kPa)
> 1,000 (6 900)	1% of set pressure

PG-72.3 The spring in a safety valve or safety relief valve shall not be reset for any pressure more than 5% above or below that for which the valve is marked unless the new setting is within the spring design range established by the manufacturer or is determined to be acceptable to the manufacturer.

If the set pressure is to be adjusted within the limits specified above, the adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. An additional valve data tag identifying the

new set pressure, capacity, and date shall be furnished and installed, and the valve shall be resealed.

PG-72.4 If the set pressure of a valve is changed so as to require a new spring, the spring shall be acceptable to the manufacturer. The spring installation and valve adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. A new nameplate as described in PG-110 shall be furnished and installed, and the valve shall be resealed.

PG-73 MINIMUM REQUIREMENTS FOR SAFETY AND SAFETY RELIEF VALVES**PG-73.1 Mechanical Requirements**

PG-73.1.1 The design shall incorporate guiding arrangements necessary to insure consistent operation and tightness.

PG-73.1.2 The spring shall be designed so that the full lift spring compression shall be no greater than 80% of the nominal solid deflection. The permanent set of the spring (defined as the difference between the free height and height measured 10 min after the spring has been compressed solid three additional times after presetting at room temperature) shall not exceed 0.5% of the free height.

PG-73.1.3 To provide a means for verifying whether it is free, each safety valve or safety relief valve shall have a substantial lifting device, which when activated will release the seating force on the disk when the valve is subjected to pressure of at least 75% of the set pressure. The lifting device shall be such that it cannot lock or hold the valve disk in lifted position when the exterior lifting force is released. Disks of safety relief valves used on high-temperature water boilers shall not be lifted while the temperature of the water exceeds 200°F (93°C). If it is desired to lift the valve disk to assure that it is free, this shall be done when the valve is subjected to a pressure of at least 75% of the set pressure. For high-temperature water boilers, the lifting mechanism shall be sealed against leakage.

PG-73.1.4 The seat of a safety valve shall be fastened to the body of the valve in such a way that there is no possibility of the seat lifting.

PG-73.1.5 A body drain below seat level shall be provided in the valve and this drain shall not be plugged during or after field installation. For valves exceeding NPS 2½ (DN 65), the drain hole or holes shall be

tapped not less than NPS $\frac{3}{8}$ (DN 10). For valves of NPS $2\frac{1}{2}$ (DN 65) or smaller, the drain hole shall not be less than $\frac{1}{4}$ in. (6 mm) in diameter.

PG-73.1.6 In the design of the body of the valve, consideration shall be given to minimizing the effects of water deposits.

PG-73.1.7 Valves having screwed inlet or outlet connections shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

PG-73.1.8 Means shall be provided in the design of all valves for use under this Section, for sealing all external adjustments. Seals shall be installed by the manufacturer, his authorized representative, or an assembler at the time of the initial adjustment. After spring replacement and/or subsequent adjustment, the valve shall be resealed. Seals shall be installed in such a manner as to prevent changing the adjustment without breaking the seal and, in addition, shall serve as a means of identifying the manufacturer, his authorized representative, or the assembler making the adjustment.

PG-73.2 Material Selections

PG-73.2.1 Cast iron seats and disks are not permitted.

PG-73.2.2 Adjacent sliding surfaces such as guides and disks or disk holders shall both be of corrosion resistant material. Springs of corrosion resistant material or having a corrosion resistant coating are required. The seats and disks of safety valves or safety relief valves shall be of suitable material to resist corrosion by the lading fluid.

NOTE: The degree of corrosion resistance, appropriate to the intended service, shall be a matter of agreement between the manufacturer and the purchaser.

PG-73.2.3 Materials used in bodies and bonnets or yokes shall be listed in Section II, Parts A and B, and identified in Tables 1A and 1B of Section II, Part D, as permitted for Section I construction. Materials used in nozzles, disks, and other parts contained within the external structure of the safety or safety relief valves shall be one of the following categories:

- (1) listed in ASME Section II;
- (2) listed in ASTM Specifications (see Note below);
- (3) controlled by the manufacturer of the safety or safety relief valve by a specification insuring control of chemical and physical properties and quality at least equivalent to ASTM Standards (see Note below).

NOTE: It shall be the manufacturer's responsibility to insure that the allowable stresses at temperature meet the requirements of Section II, Part D, Appendix 1, Nonmandatory Basis for Establishing Stress Values in Tables 1A and 1B.

PG-73.3 Inspection of Manufacturing and/or Assembly

PG-73.3.1 A manufacturer shall demonstrate to the satisfaction of an ASME designee that his manufacturing, production, and test facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for capacity certification.

PG-73.3.2 Manufacturing, assembly, inspection, and test operations including capacity, are subject to inspections at any time by an ASME designee.

PG-73.3.3 A Manufacturer or assembler may be granted permission to apply the V Code Symbol to production pressure relief valves capacity-certified in accordance with PG-69, provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. This permission may be extended for 5 year periods if the following tests are successfully repeated within the 6 month period before expiration.

(1) Two sample production pressure relief valves of a size and capacity within the capability of an ASME accepted laboratory shall be selected by an ASME designee.

(2) Operational and capacity tests shall be conducted in the presence of an ASME designee at an ASME accepted laboratory. The valve manufacturer or assembler shall be notified of the time of the test and may have representatives present to witness the test.

(3) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements in PG-72, the test shall be repeated at the rate of two replacement valves, selected in accordance with PG-73.3.3(1), for each valve that failed.

(4) Failure of any of the replacement valves to meet capacity or the performance requirements of this Section shall be cause for revocation within 60 days of the authorization to use the Code symbol on that particular type of valve. During this period, the Manufacturer or assembler shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of PG-73.3.3 above shall apply.

PG-73.3.4 Use of the Code Symbol Stamp by an assembler indicates the use of original unmodified parts in strict accordance with the instructions of the

manufacturer of the valve. However, an assembler may convert original finished parts by machining to another finished part for a specific application under the following conditions:

(a) Conversions shall be specified by the Manufacturer. Drawings and/or written instructions used for part conversion shall be obtained from the Manufacturer and shall include a drawing or description of the converted part before and after machining.

(b) The Assembler's quality control system, as accepted by a representative from an ASME designated organization, must describe in detail the conversion of original parts, provisions for inspection and acceptance, personnel training, and control of current Manufacturer's drawings and/or written instructions.

(c) The Assembler must document each use of a converted part.

(d) The Assembler must demonstrate to the Manufacturer the ability to perform each type of conversion. The Manufacturer shall document all authorizations granted to perform part conversions. The Manufacturer and Assembler shall maintain a file of such authorizations.

(e) At least annually a review shall be performed by the Manufacturer of an Assembler's system and machining capabilities. The Manufacturer shall document the results of these reviews. A copy of this documentation shall be kept on file by the Assembler. The review results shall be made available to a representative from an ASME designated organization.

NOTE: Within the requirements of PG-73.3 and PG-73.4, a *manufacturer* is defined as a person or organization who is completely responsible for design, material selection, capacity certification, manufacture of all component parts, assembly, testing, sealing, and shipping of safety and safety relief valves certified under this Section.

An *assembler* is defined as a person or organization who purchases or receives from a manufacturer the necessary component parts or valves and assembles, adjusts, tests, seals, and ships safety or safety relief valves certified under this Section at a geographical location other than and using facilities other than those used by the manufacturer.

PG-73.4 Testing by Manufacturers or Assemblers

PG-73.4.1 Valves exceeding 1 in. (DN 25) inlet size or 300 psig (2 070 kPa) set pressure shall meet the following requirements. Primary pressure containing cast and welded parts of pressure relief valves shall be tested at a pressure at 1.5 times the design pressure of the parts. These tests shall be conducted after all machining operations to the parts have been completed. There shall be no visible signs of leakage.

Closed bonnet pressure relief valves designed for discharge to a closed system shall be tested with a minimum of 30 psig (207 kPa) air or other gas in the

secondary pressure zone. There shall be no visible signs of leakage.

PG-73.4.2 Every valve shall be tested with steam by the manufacturer or assembler to demonstrate the popping point, blowdown, tightness, and pressure containing integrity. Valves beyond the capability of production test facilities may be shop tested with air, provided required field tests and applicable adjustments are made.

PG-73.4.3 A seat tightness test shall be conducted at maximum expected operating pressure, but at a pressure not exceeding the reseating pressure of the valve. When being tested, a valve exhibiting no visible signs of leakage shall be considered adequately tight.

PG-73.4.4 A manufacturer or assembler shall have a documented program for the application, calibration, and maintenance of test gages.

PG-73.4.5 Testing time on steam valves shall be sufficient to assure that test results are repeatable and representative of field performance.

PG-73.4.6 Test fixtures and test drums, where applicable, shall be of adequate size and capacity to assure that the observed set pressure is consistent with the stamped set pressure within the tolerance required by PG-72.2.

PG-73.5 Design Requirements. At the time of submission of valves for capacity certification or testing in accordance with PG-69, the ASME designee has the authority to review design for conformity with the requirements of this Section and to reject or require modification of designs that do not conform, prior to capacity testing.

FABRICATION

PG-75 GENERAL

The fabrication of boilers and parts thereof shall conform to the general fabrication requirements in the following paragraphs and in addition to the specific requirements for fabrication in the Parts of this Section that pertain to the methods of construction used.

PG-76 CUTTING PLATES AND OTHER STOCK

PG-76.1 Plates may be cut by machining, punching, shearing, or cutting by the electric arc or gas process,

providing enough metal is left at any unfinished edges to meet the requirements of PG-79.

PG-76.2 When end faces of nozzle or manhole necks are to remain unwelded in the completed vessel, these end faces shall not be cut by shearing unless at least $\frac{1}{8}$ in. (3.2 mm) of additional metal is removed by any method that will produce a smooth finish.

PG-77 PLATE IDENTIFICATION

PG-77.1 When the boiler is completed, there shall remain visible on shell plates, furnace sheets, and heads, one group of the plate manufacturer's stamps, consisting of the manufacturer's name, plate identification number, material specification number with grade, class, and type as appropriate, except that heads containing tube holes and buttstraps shall have visible at least a sufficient portion of such stamps for identification.

PG-77.2 It is permissible for an authorized representative of the boiler Manufacturer to transfer the markings on the plate provided a record is made of such transfer. In lieu of the above and PG-77.1, identification may be by applying a coded marking traceable to the original required markings or by recording the required markings using methods such as material tabulations or as built sketches which assure identification of each piece of material during fabrication and subsequent identification in the completed boiler. Such transfers of markings shall be made prior to cutting, except that the Manufacturer may transfer markings immediately after cutting, provided the control of these transfers is described in his written Quality Control System (A-300). The procedure for making such transfer shall be acceptable to the Authorized Inspector.

PG-77.3 An authorized representative of the plate manufacturer may duplicate the required stamping on any material wherever located.

PG-77.4 When plate specification heat treatments are not performed by the mill, they shall be performed by or under the control of the fabricator, who shall then place the letter "T" following the letter "G" in the mill plate marking (see SA-20) to indicate that the material specification heat treatments have been performed. The fabricator shall also show by a supplement to the appropriate Mill Test Report that the specified heat treatment has been performed.

PG-78 REPAIRS OF DEFECTS IN MATERIALS

Defects in material may be repaired by the boiler Manufacturer provided acceptance by the Inspector is first obtained for the method and extent of repairs. Material that cannot be satisfactorily repaired shall be rejected.

PG-79 TUBE HOLES AND ENDS

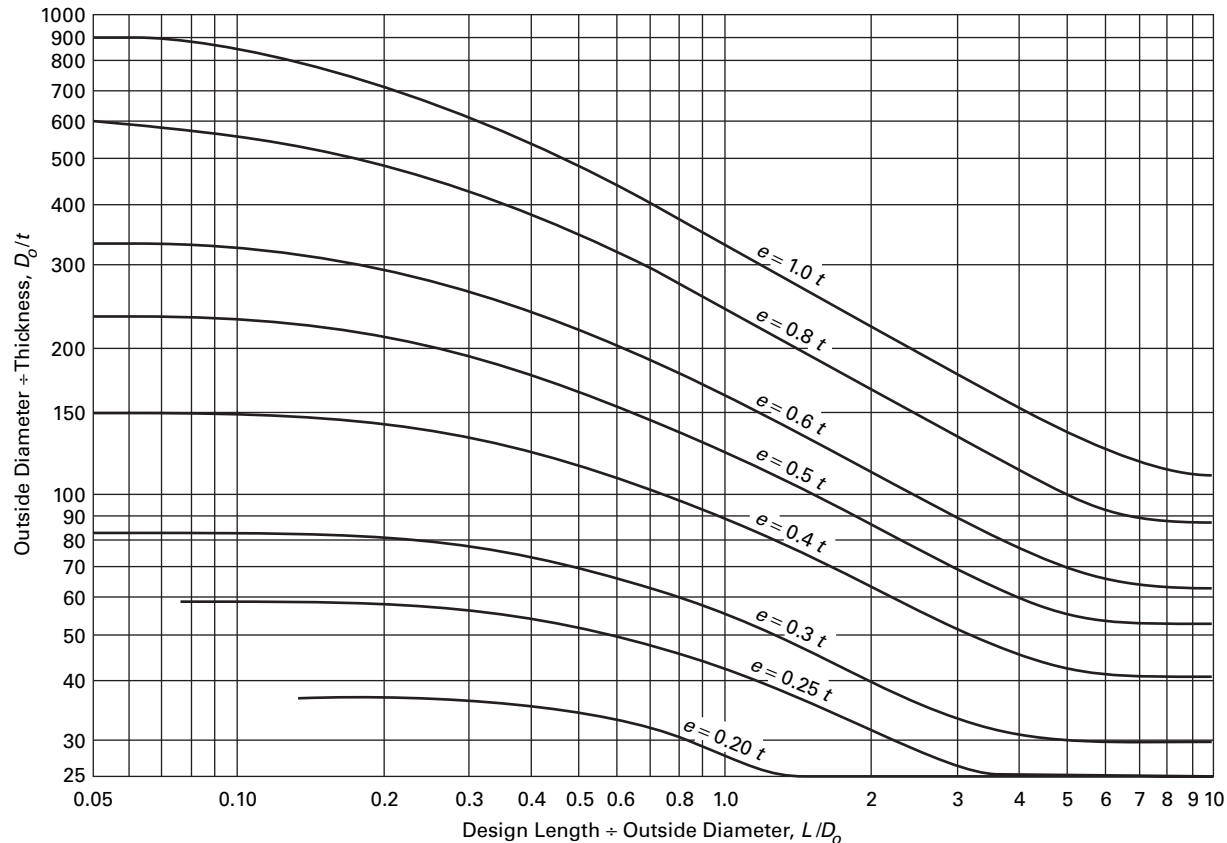
Tube holes shall be drilled full size from the solid plate, or they may be punched at least $\frac{1}{2}$ in. (13 mm) smaller in diameter than full size, and then drilled, reamed, or finished full size with a rotating cutter. The thermal- or plasma-arc cut holes, when made, shall be sufficiently smaller in diameter than full size, such that subsequent machining to full size shall completely remove all metal whose mechanical and metallurgical properties have been affected as a result of the thermal- or plasma-arc cutting. Tube holes may be counterbored where the metal is thicker than that required to get a proper bearing by expanding, so as to form narrow seats into which the tube ends can be properly expanded, provided there is space available to permit a proper amount of flare of the tube end.

The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

PG-80 PERMISSIBLE OUT-OF-ROUNDNESS OF CYLINDRICAL SHELLS

PG-80.1 Internal Pressure. The cylinder or barrel of a drum or shell shall be circular at any section within a limit of 1% of the mean diameter, based on the differences between the maximum and minimum mean diameters at any section, and if necessary to meet this requirement shall be reheated, rerolled, or reformed. To determine the difference in diameters, measurements may be made on the inside or the outside, and when the cylinder or barrel is made of plates of unequal thicknesses, the measurements shall be corrected for the plate thicknesses as they may apply, to determine the diameters at the middle line of the plate thickness.

PG-80.2 External Pressure. Welded cylindrical furnaces and other cylindrical parts subjected to external pressure shall be rolled to practically a true circle with a maximum plus or minus deviation not to exceed the following:



GENERAL NOTES:

(a) The above chart applies to cylinders over 24 in. (610 mm) O.D.

(b) Use the curves $e = 1.0t_s$ or $e = 0.2t_s$, respectively, for points falling above or below those curves.FIG. PG-80 MAXIMUM PERMISSIBLE DEVIATION FROM A CIRCULAR FORM e FOR CYLINDRICAL PARTS UNDER EXTERNAL PRESSURE

(a) For components greater than 24 in. (610 mm) O.D., the maximum permissible deviation, “ e ,” shall be obtained from Fig. PG-80. The symbols L , D_o , and t_s are as defined in PFT-51.1.1.

(b) For components equal to or less than 24 in. (610 mm) O.D., the maximum deviation shall not exceed 1% of the O.D.

PG-81 TOLERANCE FOR FORMED HEADS

When heads are made to an approximate ellipsoidal shape, the inner surface of such heads must lie outside and not inside of a true ellipse drawn with the major axis equal to the inside diameter of the head and one-half the minor axis equal to the depth of the head.

The maximum variation from this true ellipse shall not exceed 0.0125 times the inside diameter of the head.

PG-82 HOLES FOR STAYS

PG-82.1 Holes for threaded stays shall be drilled full size or punched and subsequently drilled or reamed. Punched holes shall not exceed $\frac{1}{4}$ in. (6 mm) less than full diameter for plates over $\frac{5}{16}$ in. (8 mm) or $\frac{1}{8}$ in. (3.2 mm) less than full diameter for plates not exceeding $\frac{5}{16}$ in. (8 mm) thickness prior to finished drilling or reaming. Threaded holes shall be tapped fair and true with a full thread.

PG-82.2 Holes for welded stays shall be cut and prepared in accordance with PW-29.

INSPECTION AND TESTS

PG-90 GENERAL

PG-90.1 Each boiler, superheater, waterwall, or steel economizer shall be inspected during construction and after completion by an Authorized Inspector (AI). The AI may perform inspections at other stages of the work as he may designate. (PW-46.2) Each Manufacturer or Assembler is required to arrange for the services of Authorized Inspectors (see Foreword and PG-91) to perform inspections on all of his work within the scope of this Section, whether performed in the shop or in the field. Duties of the AI are described elsewhere in this Section and include the following:

PG-90.1.1 Verifying that the Manufacturer or Assembler has a valid ASME Certificate of Authorization covering the scope of his Code activities (PG-104.2.1, PG-105.5).

PG-90.1.2 Monitoring compliance with the accepted Quality Control Program and verifying that any changes meet the requirements of this Section (PG-105.4, PEB-18, A-300).

PG-90.1.3 Verifying that the Certificate Holder has the necessary Code books, Addenda, and Code Cases to cover the work being performed.

PG-90.1.4 Reviewing a selected number of the Manufacturer's design calculations to verify compliance with Section I (PG-90.3).

PG-90.1.5 Witnessing and approving proof tests to establish Maximum Allowable Working Pressure (MAWP) (A-22).

PG-90.1.6 Verifying that the Certificate Holder has sufficient material control to assure that material used for construction complies with the applicable requirements of this Section (PG-10, PG-11, PG-105.4, A-302.4).

PG-90.1.7 When cutting plate material into two or more pieces is necessary, verifying that the Certificate Holder's controls provide a positive means of identification to maintain traceability of materials (PG-77.2, A-302.4).

PG-90.1.8 Verifying that the Certificate Holder's personnel are examining cut edges before welding (PW-29.3).

PG-90.1.9 Verifying that all welding procedure specifications, procedure qualification records, welder and welding operator qualification records conform to

the requirements of this Section (PW-1.2, PW-28, PW-40.2, PW-47, PW-48, PW-53).

PG-90.1.10 If welded repairs are necessary, accepting the method and extent of repairs and verifying that only qualified welding procedures, welders, and welding operators are used (PG-78, PW-40.2, PW-54.2).

PG-90.1.11 Verifying that all required heat treatments have been performed and are properly documented (PW-11.3.4, PW-39, PW-49).

PG-90.1.12 Verifying that required nondestructive examinations and tests have been performed by qualified personnel and that the results are properly documented (PG-25.2, PW-11, PW-51, PW-52).

PG-90.1.13 Performing the required inspections and witnessing hydrostatic tests (PG-99, PW-54).

PG-90.1.14 Verifying that the responsible representative of the Certificate Holder has signed the Data Report and that it is correct before being signed (PG-104, PG-112, PG-113, PW-1.2.5).

PG-90.1.15 Prior to stamping, verifying that the item is in compliance with the requirements of this Section. After stamping, verifying that the stamping is correct and that the nameplate, if used, has been properly attached (PG-106, PG-108, PG-109, PW-1.2.5).

PG-90.3 The Manufacturer is responsible for the preparation of design calculations to show compliance with the rules of Section I and his signature on the Manufacturers' Data Report Form shall be considered to include certification that has been done. The Manufacturer shall make available such design calculations as the Authorized Inspector may request. The Authorized Inspector has the duty to review a selected number of the Manufacturer's design calculations to verify compliance with Section I.

PG-91 QUALIFICATION OF INSPECTORS

The inspection required by this Section shall be by an Inspector employed by an ASME accredited Authorized Inspection Agency,²² that is, the inspection organization of a state or municipality of the United States, a Canadian province, or of an insurance company authorized to write boiler and pressure vessel insurance. These Inspectors shall have been qualified by written

²² Whenever *Authorized Inspection Agency* or *AIA* is used in this Code, it shall mean an Authorized Inspection Agency accredited by ASME in accordance with the requirements in the latest edition of ASME QAI-1, Qualification for Authorized Inspection.

examination under the rules of any state of the United States or province of Canada which has adopted the Code.

PG-93 INSPECTION AND REPAIR OF FLAT PLATE IN CORNER JOINTS

PG-93.1 When flat plate greater than $\frac{1}{2}$ in. (13 mm) thickness is welded to other pressure parts to form a corner joint, such as in flat heads [Fig. PG-31, sketches (g) and (i)], waterlegs of firebox boilers or combustion chambers of wetback boilers [Fig. A-8, sketches (l), (m), (n), and (p)], and the exposed edges of the plate are closer to the edge of the weld than a distance equal to the thickness of the plate, the peripheral plate edges and any remaining exposed surface of the weld joint preparation shall be examined after welding by either the magnetic particle or liquid penetrant method. When the plate is nonmagnetic, only the liquid penetrant method shall be used. The requirements of this paragraph shall not apply to those joints when 80% or more of the pressure load is carried by tubes, stays, or braces, or when the exposed edges of the plate are farther from the edge of the weld than a distance equal to the thickness of the plate.

PG-93.2 Laminations, cracks, or other imperfections found during the examination required by PG-93.1 that would affect the safety of the vessel shall be repaired in accordance with PG-78. The imperfection(s) may be pursued by any suitable method (grinding, chipping, etc.). The repaired area shall be subjected to the same examination that first revealed the imperfection.

PG-93.3 Methods and acceptance criteria for magnetic particle and liquid penetrant examination shall be in accordance with A-260 or A-270 respectively.

PG-99 HYDROSTATIC TEST

Hydrostatic testing of the completed boiler unit shall be conducted in accordance with the following requirements:

After a boiler has been completed (see PG-104), it shall be subjected to pressure tests using water at no less than ambient temperature, but in no case less than 70°F (21°C). At no time during the hydrostatic test shall any part of the boiler be subjected to a general primary membrane stress greater than 90% of its yield strength (0.2% offset) at test temperature. The primary membrane stress to which the boiler components are subjected during hydrostatic testing shall be taken into account when designing the components. When the

boiler is completed in the Manufacturer's shop without boiler external piping, subsequent hydrostatic testing of the boiler external piping shall be the responsibility of any holder of a valid "S," "A," or "PP" stamp. The safety valves need not be included in the hydrostatic test. The tests shall be made in two stages in this sequence:

PG-99.1 Hydrostatic pressure tests shall be applied by raising the pressure gradually to $1\frac{1}{2}$ times the maximum allowable working pressure as shown on the data report to be stamped on the boiler. The pressure shall be under proper control at all times so that the required test pressure is never exceeded by more than 6%. Close visual inspection for leakage is not required during this stage.

PG-99.2 The hydrostatic test pressure may then be reduced to the maximum allowable working pressure, as shown on the Data Report, to be stamped on the boiler and maintained at this pressure while the boiler is carefully examined. The metal temperature shall not exceed 120°F (49°C) during the close examination.

PG-99.3 A completed forced-flow steam generator with no fixed steam and waterline, having pressure parts designed for different pressure levels along the path of water-steam flow, shall be subjected to a hydrostatic pressure test by the above procedure (PG-99.1 and PG-99.2) based upon:

PG-99.3.1 For the first stage test (PG-99.1) a hydrostatic test pressure of not less than $1\frac{1}{2}$ times the maximum allowable working pressure at the superheater outlet as shown in the master stamping (PG-106.3) but no less than $1\frac{1}{4}$ times the maximum allowable working pressure of any part of the boiler, excluding the boiler external piping.

PG-99.3.2 For the second stage test (PG-99.2) the hydrostatic test pressure may be reduced to not less than the maximum allowable working pressure at the superheater outlet.

PG-99.4 Test Gages

PG-99.4.1 An indicating gage, visible to the operator controlling the pressure applied, shall be connected to the pressure parts. Hydrostatic head on the gage shall be considered depending on the location of the gage.

PG-99.4.2 Dial pressure gages used in testing shall preferably have dials graduated over their entire range of about double the intended maximum test pressure, but in no case shall the range be less than $1\frac{1}{2}$ times that pressure. The spacing between graduations shall be such that the inspector and the operator controlling

the test shall be able to determine when the required test pressure has been applied. Digital pressure gages having a wider range of pressure readings may be used provided the readings give the same or greater degree of accuracy as obtained with dial pressure gages.

PG-100 HYDROSTATIC DEFORMATION TEST

Where no rules are given and it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the Manufacturer and tested in accordance with the Standard Practice for Making a Hydrostatic Test on a Boiler Pressure Part to Determine the Maximum Allowable Working Pressure, given in A-22 or in such other manner as the Committee may prescribe.

CERTIFICATION BY STAMPING AND DATA REPORTS

PG-101 HEATING SURFACE COMPUTATION

PG-101.1 For the stamping required by PG-106, the heating surface shall be computed as follows:

PG-101.1.1 Heating surface, as part of a circulating system in contact on one side with water or wet steam being heated and on the other side with gas or refractory being cooled, shall be measured on the side receiving heat.

PG-101.1.2 Boiler heating surface and other equivalent surface outside the furnace shall be measured circumferentially plus any extended surface.

PG-101.1.3 Waterwall heating surface and other equivalent surface within the furnace shall be measured as the projected tube area (diameter $\times$ length) plus any extended surface on the furnace side. In computing the heating surface for this purpose, only the tubes, fire-boxes, shells, tubesheets, and the projected area of headers need to be considered, except that for vertical firetube steam boilers only that portion of the tube surface up to the middle of the gage glass is to be computed.

PG-104 GENERAL

PG-104.1 The completed boiler unit includes all piping and piping components as defined in the Preamble.

The Manufacturer (see Note 1 below) of any complete boiler unit to be stamped with the Code symbol has the responsibility of assuring through proper Code certification that all work performed by him or others responsible to him complies with all requirements of the Code, including design, construction, materials, and workmanship. With the exception of field installed boiler external piping, when some portions of a complete boiler unit are supplied by, or Code work is performed by others not responsible to the Manufacturer, the Manufacturer has the duty of obtaining from these other organizations their proper Code certification, covering such portions of work.

When the Manufacturer furnishes a shop assembled boiler that is complete except for boiler external piping, and the boiler has been hydrostatically tested in the shop and properly stamped with the Manufacturer's "S" symbol, the subsequent installation in the field of the external piping within the scope of Section I is not by itself considered "field assembly of the boiler" (see Note 2 below).

No Manufacturer or assembler may accept Code responsibility for work that falls within the scope of the Code, that is performed by workmen employed by any other organization, except through proper Code certification. The responsibilities set forth herein relate only to Code compliance and are not to be construed as involving contractual relations or legal liabilities.

NOTE 1: Boiler Manufacturer or Manufacturer as used in PG-104 or other paragraphs referenced to this Note may also be an Engineering-Contractor organization with or without fabricating facilities, but having the capability of providing a design specification that establishes the pressure and temperature conditions for each component of a complete boiler unit and of assembling the fabricated parts in the field with authorization from the Society to use the Code symbol stamp "S" in accordance with the Code provisions in PG-105.3.

NOTE 2: When boiler external piping within the scope of Section I is furnished by other than the boiler Manufacturer, the boiler Manufacturer is not responsible for the Code certification of such piping. The organizations that furnish and that install such external piping by welding shall furnish proper Code certification (PG-104.2) for such piping including Manufacturers' Data Report Form P-4A as required by PG-112.2.5 and PG-112.3.

PG-104.2 Proper Code certification refers to the furnishing of stamping and Data Reports as evidence to establish the following.

PG-104.2.1 The organization that performed that portion of the work held an appropriate Certificate of Authorization.



FIG. PG-105.1 OFFICIAL SYMBOLS FOR STAMPS TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR BOILERS



FIG. PG-105.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR ASSEMBLY

FIG. PG-105.3 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR WELDED PIPING



FIG. PG-105.4 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR SAFETY VALVES

PG-104.2.2 By signing and furnishing the appropriate data report, that organization certified compliance with Code rules for that portion of the work.

PG-104.2.3 By proper use of the Code symbol stamp, that organization identified the portions of the work covered by its Data Report Form.

PG-104.2.4 By countersignature on the same Data Report a qualified Inspector confirmed that portion of the work complied with applicable Code rules.

PG-105 CODE SYMBOL STAMPS

PG-105.1 Authorization. Except as permitted in PG-105.6, no organization may assume responsibility for Code construction without having first received

from the ASME a Certificate of Authorization to use one of the Code symbol stamps shown in Figs. PG-105.1 through PG-105.4. There are six such stamps, defined as follows:

- S — power boiler symbol
stamp see Fig. PG-105.1
- M — miniature boiler symbol
stamp see Fig. PG-105.1
- E — electric boiler symbol
stamp see Fig. PG-105.1
- A — boiler assembly symbol
stamp see Fig. PG-105.2
- PP — pressure piping symbol
stamp see Fig. PG-105.3
- V — safety valve symbol
stamp see Fig. PG-105.4

Stamps for applying the Code symbol shall be obtained from the Society. Each boiler, superheater, waterwall, economizer, or boiler part to which a Code symbol is to be applied shall be fabricated by a Manufacturer who is in possession of an appropriate Code symbol stamp. A Certificate of Authorization to use the Code symbol "S," "M," "E," "A," "PP," or "V" stamp will be granted by the Society pursuant to the provisions of these paragraphs.

PG-105.2 Application for Certificate of Authorization. Any organization desiring a Certificate of Authorization shall apply to the Boiler and Pressure Vessel Committee of the Society, on forms issued by the Society, specifying the stamp desired and the scope of Code activities to be performed. When an organization intends to build Code items in plants in more than one geographical area, separate applications for each plant or a single application listing the addresses of all such plants may be submitted. Each application shall identify the Authorized Inspection Agency providing Code inspection at each plant. A separate Certificate of Authorization will be prepared and a separate fee charged by the Society for each plant.

Each applicant must agree that each Certificate of Authorization and each Code symbol stamp are at all times the property of the Society, that they will be used according to the rules and regulations of this Section of the Code, and that they will be promptly returned to the Society upon demand, or when the applicant discontinues the Code activities covered by his certificate, or when the Certificate of Authorization has expired and no new certificate has been issued. The holder of a Code symbol stamp shall not allow any other organization to use it.

Authorization to use Code symbol stamps may be granted or withheld by the Society in its absolute discretion. If authorization is granted, and the proper administrative fee paid, a Certificate of Authorization evidencing permission to use any such symbol, expiring on the triennial anniversary date thereafter, will be forwarded to the applicant. Each such certificate will identify the Code symbol to be used, and the type of shop and/or field operations for which authorization is granted. (See Appendix A-370.) The certificate will be signed by the Chairman of the Boiler and Pressure Vessel Committee and the Director of Accreditation. Six months prior to the date of expiration of any such certificate, the applicant must apply for a renewal of such authorization and the issuance of a new certificate. The Society reserves the absolute right to cancel or refuse to renew such authorization returning *pro rata*, fees paid for the unexpired term.

PG-105.3 Agreement With Authorized Inspection Agency. As a condition of obtaining and maintaining a Certificate of Authorization to use the “S,” “M,” “E,” “A,” or “PP” Code symbol stamps, the Manufacturer or Assembler must have in force at all times, an inspection contract or agreement with an Authorized Inspection Agency as defined in PG-91 to provide inspection services. This inspection contract is a written agreement between the Manufacturer or Assembler and the inspection agency that specifies the terms and conditions under which the inspection services are to be furnished and that states the mutual responsibilities of the Manufacturer or Assembler and the Authorized Inspectors. The certificate holder shall notify the Society whenever its agreement with an Authorized Inspection Agency is cancelled or changed to another Authorized Inspection Agency.

Manufacturers or assemblers of safety valves are not required to have an inspection agreement with an Authorized Inspection Agency. A Certificate of Authorization may be granted to a manufacturer or assembler of safety valves to use the safety valve symbol stamp providing such stamp is applied only to safety valves that have been capacity certified in accordance with the requirements of this Section.

PG-105.4 Quality Control System. Any Manufacturer or Assembler holding or applying for a Certificate of Authorization to use the “S,” “M,” “E,” “A,” “PP,” or “V” stamp shall have, and demonstrate, a quality control system to establish that all Code requirements including material, design, fabrication, examination (by the Manufacturer), and inspection for boilers and boiler parts (by the Authorized Inspector) will be met. The

quality control system shall be in accordance with the requirements of Appendix A-300.

Before issuance or renewal of a Certificate of Authorization for use of the “S,” “M,” “E,” “A,” or “PP” stamps, the Manufacturer’s facilities and organization are subject to a joint review by a representative of his inspection agency and an individual certified as an ASME designee who is selected by the concerned legal jurisdiction. When the jurisdiction assumes responsibility for leading the review, it shall have certified that its representative has met ASME criteria. A written description or checklist of the quality control system which identifies what documents and what procedures the Manufacturer will use to produce a Code item shall be available for review. The purpose of the review is to evaluate the applicant’s quality control system and its implementation. The applicant shall demonstrate sufficient administrative and fabrication functions of the system to show that he has the knowledge and ability to produce the Code items covered by his quality control system. Fabrication functions may be demonstrated using current work, a mock-up, or a combination of the two. A written report to the Society shall be made jointly by the jurisdiction and the inspection agency employed by the Manufacturer to do his Code inspection. This report is then reviewed by the Subcommittee on Boiler and Pressure Vessel Accreditation, which will either issue a Certificate of Authorization or notify the applicant of deficiencies revealed by the review. In such a case, the applicant will be given an opportunity to explain or correct these deficiencies.

Certificates of Authorization will be endorsed to indicate the scope of activity authorized. Authorization may include field operations if the review team determines that these operations are adequately described in the quality control manual, and this determination is accepted by the Society.

Before issuance or renewal of a Certificate of Authorization for use of the “V” stamp, the valve manufacturer’s or assembler’s facilities and organization are subject to a review by an ASME designee. A written description or checklist of the quality control system, which identifies the documents and procedures the manufacturer or assembler will use to produce Code safety and safety relief valves, shall be available for review. The ASME designee shall make a written report to the Society, where the Subcommittee on Boiler and Pressure Vessel Accreditation will act on it as described above.

The Manufacturer may at any time make changes in the quality control system concerning the methods of achieving results subject to acceptance by the Authorized Inspector. For manufacturers and assemblers of

“V” stamped safety or safety relief valves, such acceptance shall be by the ASME designee.

For those areas where there is no jurisdiction or where a jurisdiction does not choose to select an ASME designee to review a vessel or vessel parts manufacturer's facility, that function shall be performed by an ASME designee selected by ASME. In either case, the ASME designee shall certify its representative has met ASME criteria. Where the jurisdiction is the Manufacturer's inspection agency, the joint review and joint report shall be made by the jurisdiction and another representative designated by the Society.

PG-105.5 Code Construction Before Receipt of Certificate of Authorization. When used to demonstrate his quality control system, a Manufacturer may start fabricating Code items before receipt of a Certificate of Authorization to use a Code symbol stamp under the following conditions.

- (1) The fabrication is done with the participation of the Authorized Inspector and is subject to his acceptance.
- (2) The activity shall have been performed in conformance with the applicant's accepted quality control system.
- (3) The item is stamped with the appropriate Code symbol and certified once the applicant receives his Certificate of Authorization from the Society.

PG-105.6 Regulations on Use of Code Symbol Stamps. The Boiler and Pressure Vessel Committee may at any time make such regulations concerning the issuance and use of Code symbol stamps as it deems appropriate, and all such regulations shall become binding upon the holders of any valid Certificates of Authorization.

PG-106 STAMPING OF BOILERS

PG-106.1 The Manufacturer shall stamp each boiler, superheater, waterwall, or steel economizer constructed in compliance with this Section in the presence of the Authorized Inspector, after the hydrostatic test, in the shop of the Manufacturer, except that in cases where boilers, superheaters, waterwalls, or steel economizers are not completed and hydrostatically tested before shipment, proper stamping shall be applied at the shop and the data reports required in PG-112 and PG-113 shall be signed by the same or different Inspectors who shall indicate the portions of the inspections made at the shop and the field. The stamping shall consist of the appropriate Code symbol shown in Fig. PG-105.1

	Certified by
	 (Name of Manufacturer)
	 (Max. allow. working pressure when built)
	 (Heating surface in sq ft, boiler or waterwalls)
	 (Maximum designed steaming capacity in lb/hr)
..... Manufacturer's serial number	 (Year built)

FIG. PG-106 FORM OF STAMPING

which shall be put on each piece of equipment listed above in the locations specified in PG-111, except as provided in PG-106.2.

PG-106.2 When the watertube boiler is arranged integrally with its economizer, superheater and/or waterwalls, the stamping required in PG-106.1 for such parts as are fabricated by the Manufacturer of the boiler may be combined into a *single* stamping located as specified in PG-111.5. Identifying marks shall be placed on all headers as required in PG-111.10, PG-111.11, and PG-111.12.

PG-106.3 For forced-flow steam generators with no fixed steam and waterline, consisting of groups of pressure parts or components designed at several different levels of maximum allowable working pressures of the appropriate Code symbol shown in Fig. PG-parts as are fabricated by the Manufacturer of the boiler, shall be combined into a single stamping. In addition, whichever Manufacturer (see PG-104, Note 1) has the responsibility for assurance of Code certification for a completed boiler unit, that Manufacturer shall provide a master stamping for the complete unit which shall show the maximum allowable working (minimum design) pressure at the superheater outlet as determined by the Manufacturer as item PG-106.4.1(3). In no case shall the master stamping pressure be more than the maximum allowable working pressure of any part of the unit, excluding the steam piping between the boiler and the prime mover. The master stamping shall be located as required in PG-111.5.2.

PG-106.4 In addition to the symbol, the following items shall also be stamped with letters and figures at least $\frac{5}{16}$ in. (8 mm) high [$\frac{5}{32}$ in. (4 mm) on miniature boilers if necessary], arranged as shown in Fig. PG-106.

PG-106.4.1 Items on Boilers

- (1) Manufacturer's serial number
- (2) Certified by (Name of Manufacturer)
- (3) Maximum allowable working pressure when built
- (4) Heating surface (or kilowatt power input for electric boilers)
- (5) Year built
- (6) Maximum designed steaming capacity, lb/hr (kg/hr) [or, for high-temperature water boilers, maximum designed output, Btu/hr (J/hr)]

PG-106.4.2 Items on Waterwalls, Superheaters, or Steel Economizers

- (1) Manufacturer's serial number
- (2) Certified by (Name of Manufacturer)
- (3) Maximum allowable working pressure when built
- (4) Heating surface in square feet (not required for integral superheaters) (rated Btu per hour absorption for an isolable economizer)
- (5) For independently fired superheaters, heating surface in square feet or the minimum safety valve discharge capacity in lbs. of steam per hour calculated from the maximum expected heat absorption (as determined by the Manufacturer) in Btu/hr, divided by 1,000.

PG-106.5 For boilers with no pressure retaining part larger than 16 in. (406 mm) O.D., or for equipment operating at temperatures above 800°F (427°C), a cast, etched, or stamped metallic nameplate may be used to provide the data required by PG-106 instead of stamping directly on the pressure retaining material. This plate shall be securely attached to the item it describes. If the attachment is by welding, the welding shall meet the requirements of this Section. The Authorized Inspector shall witness the stamping of the Code symbol and verify that the nameplate has been attached.

PG-106.6 Each Manufacturer shall furnish, in addition, a metallic plate or plates on which the above data are reproduced for all the items manufactured by him, except when the original stampings are so located on the completed (or assembled) boiler unit that all will be readily visible from one place on the operating floor or platform. These plates, if used, shall be located as specified in PG-111.13. All data on such additional plates, including the Code symbol, shall be cast, etched, or stamped and this marking need not be witnessed by an Authorized Inspector. The letters and figures on these nameplates shall be not less than $\frac{5}{32}$ in. (4 mm) high.

PG-106.7 When the Manufacturer is an Engineering Contractor (see PG-104, Note 1), the Engineering Contractor shall provide a metallic master stamping plate or plates. The letters and figures on this plate shall be not less than $\frac{5}{32}$ in. (4 mm) high. This plate shall include, in addition to the Code symbol, all the data required by PG-106.4. Such data, except the Code symbol, may be cast, etched, or stamped on this plate. The Code symbol shall be stamped. The stamping of the master stamping plate with the Code symbol shall be in the presence of the Authorized Inspector after the Inspector has examined the Design Specification for the complete boiler unit, verified the plate data, and is satisfied that the Engineering Contractor has provided for the construction of a complete boiler unit. The Inspector shall then sign the Certification of Engineering Contractor portion of Form P-3A.

The master stamping plate shall be located on the boiler as specified in PG-111.13 by the boiler Assembler in the presence of and when authorized by the field Inspector after the required inspections and the hydrostatic test of the completed unit. The Certificate of Field Assembly Inspection portion of Form P-3A shall then be signed by the field Inspector.

PG-106.8 Stamping and Marking of Parts

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PG-106.8.1 When only a part of the boiler is supplied and the data are recorded on Form P-4, Manufacturers' Partial Data Report (see PG-112.2.4), the part shall be stamped with:

01

- (1) ASME Code Symbol above the word "part"
- (2) Certified by (Name of Manufacturer)
- (3) Manufacturer's serial number of the part
- (4) Year built

Parts may be stamped with the ASME Code Symbol without being pressure tested prior to shipment. (See PG-112 for requirements for documentation and stamping of pressure parts that do not contain pressure retaining welds.)

PG-106.8.2 In lieu of such stamping, small parts (5 in. OD and under) may be marked with an identification acceptable to the Inspector (e.g., bar coding, etching, paint stencil, etc.) and traceable to the Form P-4, Manufacturers' Partial Data Report. Such marking shall be of a type that will remain visible until the part is installed. The Code symbol stamp is not required.

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PG-106.9 No accessory or part of a boiler may be marked "ASME" or "ASME Std." unless so specified in the Code.

PG-106.10 Shell plates, furnace sheets, and heads shall have identification stamping in conformance with PG-77.

PG-106.11 The American Society of Mechanical Engineers' standard symbols and the boiler builder's stamps shall not be covered permanently by insulating or other material.

PG-106.12 Multiple Pressure Steam Generators consisting of several sections of heat exchange surface designed for different pressure levels may be considered as a single boiler and the Manufacturer's stamping required by PG-106.1 combined into a single stamping provided:

PG-106.12.1 The different circuits of the boiler are not intended to be operated separately or independently.

PG-106.12.2 The extent and design of the boiler external piping for each circuit shall be established in accordance with PG-58.3.

PG-106.12.3 The various circuits shall be separated from each other by providing a stop valve and a check valve in the feedwater piping leading to each circuit, in accordance with PG-58.3.3.

PG-106.12.4 Each circuit shall be given a hydrostatic test corresponding to its MAWP, as required by PG-99.

PG-106.12.5 Each circuit shall be stamped with the information required by PG-106.4. The stamping shall be located in accordance with PG-111.

PG-106.12.6 The Manufacturer shall furnish, in addition, a single metallic plate on which the above data are reproduced for all of the circuits. This plate shall be located in accordance with PG-111.13. All data on such plates shall be cast, etched or stamped. The Code symbol shall be stamped on this plate and shall be witnessed by an Authorized Inspector. The letter and figures on these nameplates shall be no less than $\frac{5}{32}$ in. high.

PG-107 FIELD ASSEMBLY

Code responsibility for a completed boiler unit that is field assembled (excluding the shop assembled boiler with field installed piping, see PG-104, Note 2) may be assumed only under the following conditions:

PG-107.1 By the boiler Manufacturer (see PG-104, Note 1) provided:

PG-107.1.1 Assembly work is performed by workmen employed by the boiler Manufacturer.

PG-107.1.2 Any work performed by others, such as erection of piping, that falls within the scope of the Code, is handled by proper Code certification.

PG-107.1.3 The completed boiler unit is properly stamped with the Manufacturer's "S" symbol in accordance with PG-108.1.

PG-107.1.4 Data Reports are prepared in accordance with PG-113.1.

PG-107.2 Jointly by the boiler Manufacturer (see PG-104, Note 1) and the assembler provided:

PG-107.2.1 Assembly work is performed by workmen employed by the assembler.

PG-107.2.2 The assembler uses his own properly qualified welding procedures, welders and/or welding operators.

PG-107.2.3 Any work performed in the field by others, such as erection of piping, that falls within the scope of the Code, is handled by proper Code Certification.

PG-107.2.4 The completed boiler unit is properly stamped with the Manufacturer's "S" symbol and the assembler's "A" symbol in accordance with PG-108.2.

PG-107.2.5 Data Reports are prepared in accordance with PG-113.2 and such Data Reports clearly define the work completed by the Manufacturer and the assembler.

PG-108 STAMPING FOR FIELD ASSEMBLED BOILERS

Field assembly of a completed boiler unit may be made by anyone possessing a valid Certificate of Authorization for a power boiler stamp or an assembly stamp provided responsibility is assumed in accordance with the requirements of PG-107. Stamping for field assembled boiler units shall be completed as follows.

PG-108.1 When responsibility for the completed boiler unit is assumed under PG-107.1, no additional stamping beyond that required by PG-106 is necessary.

PG-108.2 When responsibility for the completed boiler unit is assumed under PG-107.2, the Manufacturer's (see PG-104, Note 1) stamping shall be supplemented with the assembler's stamp, together with the name of the assembler or an acceptable abbreviation. This supplementary stamping shall be applied in the

field on the boiler near the stamping called for by PG-106 when authorized by the field Inspector after the required inspections and the hydrostatic test of the completed boiler unit. This supplementary stamping shall also be reproduced on a nameplate as required by PG-106.6 or PG-106.7.

PG-109 STAMPING OF PRESSURE PIPING

PG-109.1 Boiler external piping, as defined in the Preamble, may be fabricated by a manufacturer other than the Manufacturer of the boiler, provided that the manufacturer has been issued a Certificate of Authorization to use the “S” or “PP” symbol stamp. Boiler external piping may be installed by welding by a manufacturer or contractor other than the Manufacturer of the boiler, provided such an organization has been issued a Certificate of Authorization to use the “S,” “PP,” or “A” symbol stamp. When boiler external piping is installed by welding, the welding, including the qualification of welding procedures, welders, and welding operators, shall be done in accordance with the applicable rules of ASME B31.1. The welding shall be inspected by an Authorized Inspector at such stages of the work as he may elect. The organizations which fabricate or install such piping shall furnish proper code certification (PG-104.2) for it including a Manufacturers’ Data Report Form P-4A as required by PG-112.2.5 and PG-112.3.

PG-109.2 Welded boiler external piping included within the scope of this Code, over NPS 2 (DN 50), shall be stamped with a Code symbol, together with the manufacturer’s or contractor’s name and serial number. Such stamping shall be on the pipe, valve, or fitting adjacent to the welded joint farthest from the boiler. For piping operating at temperatures above 800°F (427°C) the symbol may be stamped on a nameplate that is irremovably attached by welding, provided such welding is postweld heat treated, or on a circular metal band at least $\frac{1}{4}$ in. (6 mm) thick. This band around the pipe shall be secured in such a manner as to prevent it from slipping off during handling and installation.

Welded piping NPS 2 (DN 50) or less included within the scope of this Code shall be marked with an identification acceptable to the Inspector and traceable to the required Data Report. Such marking shall be of a type that will remain visible until the piping has been installed.

PG-109.3 Parts of boilers, such as superheater, waterwall, or economizer headers, or any construction involving only welding as covered by PW-41, may be

fabricated by a manufacturer in possession of the pressure piping symbol stamp, and so stamped and reported on a Manufacturers’ Partial Data Report Form (Form P-4) as called for in PG-112.2.4.

PG-109.4 Mechanically assembled boiler external piping which contains no pressure boundary welds does not require stamping, and as such may be assembled by a non-stamp holder. Note that the responsibility for documentation and hydrostatic testing of a mechanically assembled boiler external piping must be assumed by a holder of a valid “S,” “A,” or “PP” stamp (see PG-112.2.5).

PG-110 STAMPING OF SAFETY VALVES

01

Each safety valve shall be plainly marked with the required data by the Manufacturer or Assembler (see PG-73.3.4) in such a way that the marking will not be obliterated in service. The marking shall be placed on the valve or on a nameplate securely fastened to the valve. The Code “V” symbol shall be stamped on the valve or nameplate by the Manufacturer or Assembler, as applicable. The other required data may be stamped, etched, impressed, or cast on the valve or nameplate. The marking shall include the following:

- (1) the name (or an acceptable abbreviation) of the Manufacturer and Assembler, as applicable;
- (2) Manufacturer’s design or type number;
- (3) NPS (the nominal pipe size of the valve inlet);
- (4) set pressure ____ psi (kPa);
- (5) capacity ____ lb/hr (kg/hr) (in accordance with PG-67.5 and with the valve adjusted for the blowdown permitted by PG-72);
- (6) year built, or alternatively, a coding may be marked on the valve such that the valve Manufacturer or Assembler can identify the year the valve was assembled and tested;
- (7) ASME symbol as shown in Fig. PG-105.4.

PG-111 LOCATION OF STAMPINGS

The location of the required stampings shall be as listed below. These stampings shall be left uncovered or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed. No piping, boiler appliance, or other obstructions shall interfere with reading of the stamping.

PG-111.1 Horizontal-return tubular boilers — on the front head above the central rows of tubes.

PG-111.2 Horizontal-flue boilers — on the front head above the flues.

PG-111.3 Traction, portable, or stationary boilers of the locomotive type or Star watertube boilers — on the furnace end above the handhole. Or on traction boilers of the locomotive type — on the left wrapper sheet forward of the driving wheel.

PG-111.4 Vertical firetube and vertical submerged tube boilers — on the shell above the firedoor and handhole opening.

PG-111.5 Watertube Boilers

PG-111.5.1 Drum type — on a head of the steam outlet drum near and above the manhole.

PG-111.5.2 Forced-flow steam generator with no fixed steam and waterline — the master stamping (PG-106.3) shall be located on a major pressure part, located near the main operating floor where readily visible. The Data Report Form shall record the location of the master stamping.

PG-111.6 Scotch marine boilers — on either side of the shell near the normal water level line and as near as practical to the front tubesheet.

PG-111.7 Economic boilers — on the front head, above the center row of tubes.

PG-111.8 Miniature and electric boilers — on some conspicuous and accessible place on the boiler proper, or on a stamping plate at least $\frac{3}{64}$ in. (1.2 mm) thick, permanently fastened (adhesives prohibited) to the boiler.

PG-111.9 On any of the above types where there is not sufficient space in the place designated, and for other types and new designs — in a conspicuous place on the boiler proper. The Data Report Form shall record the location of the required stamping.

PG-111.10 Superheaters — on superheater header near the outlet. Other headers shall carry identifying marks.

PG-111.11 Economizers — at a handy location on water inlet header or drums. Other headers shall carry identifying marks.

PG-111.12 Waterwalls — on one end of a lower header. Other headers shall carry identifying marks.

PG-111.13 When required by PG-106.6 and PG-106.7, the Manufacturer (see PG-104, Note 1) shall furnish a nameplate or plates on which the appropriate Code Symbol and design data for the scope of his

responsibility are permanently imprinted. The nameplate shall be securely attached to the front of the boiler, its setting or casing, at a place readily visible from the operating floor or platform.

PG-112 MANUFACTURERS' DATA REPORT FORMS

PG-112.1 Eight types of Manufacturers' Data Report Forms are shown in the Appendix under the heading "Data Report Forms and Guides" at the end of this Section. These forms shall be used by the Manufacturer (see PG-104, Note 1) to record all the items of a complete boiler unit, in accordance with the provisions of PG-112.2. When the certification of the complete boiler unit is accomplished by more than one Data Report, the principal Data Report (P-2, P-2A, P-3, P-3A, or P-5) shall be designated as the Master Data Report (see PG-113).

For forced-flow steam generators with no fixed steam and waterline, consisting of groups of pressure parts or components designed at several different pressure levels, a separate Manufacturers' Data Report shall clearly identify the pressure parts at each pressure level and show the maximum allowable working pressure. These several Data Reports shall be attached to a Master Data Report (PG-113) that shall clearly identify each component as part of the complete unit.

PG-112.2 Types of Data Report Forms. The types of Data Report Forms and the purposes for which they are to be used are as follows:

PG-112.2.1 Form P-2, Manufacturers' Data Report for All Types of Boilers Except Watertube and Electric, shall be used to record all types of boilers other than watertube boiler units and parts thereof which are included under Form P-3.

PG-112.2.1.1 Form P-2A, Manufacturers' Data Report for All Types of Electric Boilers, shall be used to record all types of electric boilers.

PG-112.2.2 Form P-3, Manufacturers' Data Report for Watertube Boilers, Superheaters, Waterwalls, and Economizers, shall be used to record all of the items comprising a watertube boiler.

The Form P-3 shall also be used to record a superheater, waterwall, or economizer when the design of such an item is certified by a manufacturer other than the boiler Manufacturer, or when such an item is to be added to an existing boiler. The item shall be stamped with the ASME "S" symbol and the additional information, as applicable, shown in PG-106.4.2.

Item 10 on Form P-3 shall be used to record other parts connected at the openings listed in Item 11 if such parts are fabricated of materials or by processes that require Code inspection. If such parts have not been connected prior to the hydrostatic test, a notation shall be made under Item 10 reading: "No parts connected to the openings listed in Item 11 except as noted."

PG-112.2.3 Form P-3A, Engineering-Contractor Data Report for a Complete Boiler Unit, shall be used when such an organization assumes the Manufacturer's Code responsibility as provided for by PG-104, Note 1. This form shall be used to certify Code responsibility for the design specification of the complete boiler unit, of which the components are individually certified by their individual manufacturers in accordance with the Code rules. This form also provides for field assembly certification.

PG-112.2.4 Form P-4, Manufacturers' Partial Data Report, shall be used to record boiler parts requiring inspection and stamping under this Section which are furnished by other than the Manufacturer responsible for the completed boiler, superheater, waterwall, or economizer.

(1) Except as provided in (2) below, Form P-4 shall be used only to provide supporting data for the information given on the Master Data Report (see PG-113) or on the Form P-3 used to record a superheater, waterwall, or economizer.

(2) When used to record parts furnished to the user of an existing boiler as replacement or repair parts, Form P-4 is sufficient and need not support a Master Data Report. A copy of the parts Manufacturers' Form P-4 shall be forwarded to the purchaser.

(3) The parts manufacturer shall indicate under "remarks" the extent to which he has performed the design functions. When the parts manufacturer performed only a portion of the design, he shall state which portion of the design he has performed.

PG-112.2.5 Form P-4A, Manufacturers' Data Report for Fabricated Piping, shall be used to record all shop or field-welded piping that falls within the scope of this Section but is not furnished by the boiler Manufacturer. Form P-4B, Manufacturers' Data Report for Field Installed Mechanically Assembled Piping, shall be used to record all field installed mechanically assembled boiler external piping. Form P-4B shall be used only for piping that contains no joints brazed or welded by the field installer.

PG-112.2.6 Form P-5, Summary Data Report for Process Steam Generators, shall be used by the Manufacturer (see PG-104, Note 1) to record all items of field-assembled process steam generators of the waste heat or heat recovery type, comprising one or more drums and one or more arrays of heat exchange surface. All such component items shall be constructed to the applicable rules of the Code and shall be certified by individual Data Report Forms executed by the component manufacturer and the Authorized Inspector. The Summary Data Report Form P-5 shall collect and list all the properly executed Data Report Forms for components comprising the complete process steam generator unit.

PG-112.2.7 Form P-6, Manufacturers' Data Report Supplementary Sheet, shall be used to record additional data where space was insufficient on a Data Report Form. This Manufacturers' Data Report Supplementary Sheet will be attached to the Manufacturers' Data Report Form where used.

PG-112.2.8 Form P-7, Manufacturers' Data Report for Safety Valves, shall be used to record required safety valves. Form P-7 shall be used as supporting data for Forms P-2, P-3, P-3A, or P-5. Form P-7 is not required for boilers certified on Form P-2A, or for boilers with a single safety valve when the safety valve size, set pressure, and capacity [lb/hr (kg/hr)] are included in the remarks section of Forms P-2 or P-3.

PG-112.3 Manufacturers' Data Reports and all associated Partial Data Reports shall be furnished to the purchaser, the inspection agency, and the state, municipal, or provincial authority at the place of installation. Partial Data Reports for pressure parts requiring inspection under this Section, and which are furnished by other than the Manufacturer having Code responsibility for the boiler or the superheater, waterwall, or economizer, shall be executed by the parts manufacturer and the Inspector in accordance with the requirements of this Section.

Except as provided in PG-112.2.4(2), the Partial Data Reports shall be forwarded, in duplicate, to the Manufacturer of the boiler or the superheater, waterwall, or economizer. These Partial Data Reports, together with his own inspection, shall be the final Inspector's authority to witness the application of the Code symbol to the boiler or the superheater, waterwall, or economizer. The Partial Data Reports shall be attached to the associated Forms P-2, P-2A, P-3, or P-5 by the Manufacturer having Code responsibility for the boiler or the superheater, waterwall, or economizer.

PG-112.4 Appendix A-350 includes nonmandatory guides to aid in the completion and certification of the Manufacturers' Data Report Forms.

PG-112.5 Multiple Pressure Steam Generators shall be documented as follows:

PG-112.5.1 Master Data Report Form P-3, P-3A, or P-5 shall be used by the Manufacturer as a Summary Data Report to record all items of a steam generator of the waste heat or heat recovery type, comprising one or more circuits of heat exchange surface designed for different pressure levels. The Summary Data Report shall list all of the properly executed data report forms for the items comprising the complete steam generator unit.

PG-112.5.2 Other forms such as P-3, P-4, P-4A, and P-6 shall be used as necessary to provide supporting information for the Summary Data Report.

PG-112.6 Manufacturer's Partial Data Report Form P-4 and stamping in accordance with PG-106 are neither required nor prohibited for pressure parts that do not contain pressure retaining welds (e.g., boiler furnace walls, floor panel assemblies, tubes with support or hanger lugs, etc.). However, the Manufacturer shall certify that the material and construction are in accordance with the requirements of this Section.

PG-112.6.1 Certification may be supplied in the form of bills of material and drawings with a statement of compliance or Certificate of Compliance from the Manufacturer.

PG-112.6.2 The Certification shall state what materials were used including size (OD and wall thickness) and which edition and addenda of the Code were used to construct the parts.

PG-112.6.3 The parts shall be clearly identified with markings traceable to the certification. The markings may be in the form of labels, tags, stamping, paint, or coded identification.

PG-113 MASTER DATA REPORT FORM

PG-113.1 The Master Data Report (using Manufacturers' Data Report Forms P-2, P-2A, P-3, P-3A, or P-5, as applicable) shall be used by the boiler Manufacturer (see PG-104, Note 1) to fully document all parts of a complete boiler unit (excluding boiler external piping; see PG-104, Note 2) as having Code certification in accordance with the Code requirements for design, construction, and workmanship.

PG-113.2 When a field-assembled boiler unit is documented by Data Forms from manufacturers other than the Manufacturer (see PG-104, Note 1) responsible for the complete boiler unit, the boiler Manufacturer shall complete the applicable Master Data Report Form by recording the required data from all supporting Data Report Forms that are required for the complete boiler unit. All Data Forms shall be securely attached to the Master Data Report. The Data Reports shall clearly separate shop fabrication from field assembly and in the case of large units, supplemental sheets may be used to record the information. The certificate of shop inspection block and the certificate of field assembly block shall clearly designate the items to be certified by the Inspector in the shop and those to be certified by the Inspector in the field. The certified Data Reports furnished by the several manufacturers shall be the shop or field Inspector's authority to accept the components fabricated by the other manufacturers and included in the construction of the complete boiler unit.

PG-113.3 The boiler Manufacturer (see PG-104, Note 1) shall have the responsibility for distributing copies of the complete Master Data Report Form (Data Report Form P-2, P-2A, P-3, P-3A, or P-5, as applicable) to the inspection agency and the required number of proper authorities.

PG-113.4 When boiler external piping is furnished by an organization not contractually responsible to the Manufacturer (see PG-104, Note 1), the organization responsible for the fabrication and installation of this piping shall have the responsibility for distributing copies of Form P-4A to the inspection agency and proper authorities.

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PART PW

REQUIREMENTS FOR BOILERS

FABRICATED BY WELDING

GENERAL

PW-1 GENERAL

PW-1.1 Scope. The rules in Part PW are applicable to boilers and component parts thereof, including piping constructed under the provisions of this Section, that are fabricated by welding and shall be used in conjunction with the general requirements in Part PG as well as with the specific requirements in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PW-1.2 Responsibility. Each Manufacturer¹ (Certificate of Authorization holder) is responsible for the welding done by his organization and shall establish the procedures and conduct the tests required in Section IX to qualify the welding procedures he uses in the construction of the weldments built under Section I and the performance tests of welders² who apply these procedures. Alternatively, AWS Standard Welding Procedure Specifications that have been accepted by Section IX may be used for Section I construction, provided the welding meets the requirements of this Section. A particular AWS Standard Welding Procedure may contain a range for a welding variable where only part of the range meets the requirements of this Section. This could apply to one or more welding variables. The Section I requirements always take precedence. Manufacturers intending to use AWS Standard Welding Procedures shall describe in their Quality Control System (A-302.7) control measures used to assure that the welding meets the requirements of this Section and Section IX. Other occurrences of the phrase “qualified in accordance with Section IX” in this Part shall be construed to permit use of AWS Standard Welding Procedures accepted by Section IX and controlled as described above. Such welding will ordinarily be done

by employees of the Manufacturer who accepts the responsibility for Code construction of the boiler or part being welded. Alternatively, the Manufacturer may perform Code welding using the services of individual welders who are not in his employ provided all the following conditions are met.

PW-1.2.1 All Code construction shall be the responsibility of the Manufacturer.

PW-1.2.2 All welding shall be performed in accordance with Manufacturer’s Welding Procedure Specifications that have been qualified by the Manufacturer in accordance with the requirements of Section IX.

PW-1.2.3 All welders shall be qualified by the Manufacturer in accordance with the requirements of QW-301.2, Section IX.

PW-1.2.4 The Manufacturer’s quality control system shall include as a minimum:

PW-1.2.4.1 A requirement for complete and exclusive administrative and technical supervision of all welders by the Manufacturer.

PW-1.2.4.2 Evidence of the Manufacturer’s authority to assign and remove welders at his discretion without involvement of any other organization.

PW-1.2.4.3 A requirement for Assignment of Welder identification symbols.

PW-1.2.4.4 Evidence that this program has been accepted by the Manufacturer’s Authorized Inspection Agency which provides the inspection service.

PW-1.2.5 The Manufacturer shall be responsible for Code compliance of the weldment including Code Symbol Stamping and providing Data Report Forms properly executed and countersigned by the Authorized Inspector.

PW-1.3 Welding Definitions. For some of the more common terms related to welding, refer to QW-492 of Section IX.

¹Manufacturer includes contractor, assembler, and installer.

²Welder includes welding operator.

MATERIALS

PW-5 GENERAL

PW-5.1 Materials used in welded construction of pressure parts shall conform to one of the specifications given in Section II and shall be limited to those specifically permitted in Part PG, Part PWT, and Part PFT and for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, for Section I construction and for which weld Group P-Numbers are assigned in Section IX.

PW-5.2 Carbon or alloy steel having a carbon content of more than 0.35% shall not be used in welded construction or be shaped by oxygen cutting or other thermal cutting processes.

PW-5.3 Austenitic stainless steel materials joined by electroslag welding shall be limited to SA-240 Grades 304 and 316, SA-182 Grades F304 and F316, and SA-351 Grade CF 8.

PW-5.4 Welding electrodes and filler metal shall be selected to provide deposited weld metal of chemical composition and mechanical properties compatible with the materials to be joined and the service conditions anticipated.

PW-5.5 Rimmed and semi-killed steels shall not be joined by the inertia and continuous drive friction welding processes.

PW-5.6 For pressure retaining welds in $2\frac{1}{4}\text{Cr-1Mo}$ materials, other than circumferential butt welds less than or equal to $3\frac{1}{2}$ in. (89 mm) in outside diameter, when design metal temperatures exceed 850°F (454°C), the weld metal shall have a carbon content greater than 0.05%.

DESIGN

PW-8 GENERAL

The rules in the following paragraphs apply specifically to the design of boilers and parts thereof that are fabricated by welding and shall be used in conjunction with the general requirements for design in Part PG, as well as with the specific requirements for design in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PW-9 DESIGN OF WELDED JOINTS

PW-9.1 Longitudinal, circumferential, and other joints, uniting the material used for drums, shells, or

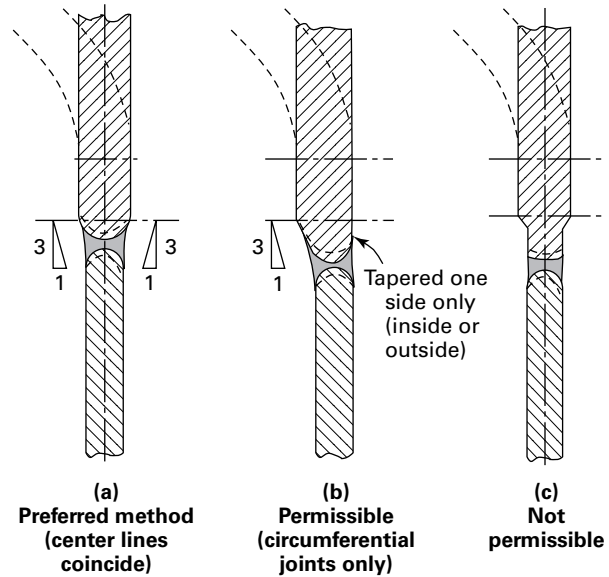


FIG. PW-9.1 BUTTWELDING OF PLATES OF UNEQUAL THICKNESS

other pressure parts, except as otherwise provided in PG-31, PG-39, PW-41, PWT-11, and Part PFT shall be full penetration butt welds. The welds should preferably be of the double-welded butt type, but may also be of the single-welded butt type with the filler metal added from one side only when made to be the equivalent of the double-welded butt joint by providing means for accomplishing complete penetration.

PW-9.2 Welding Grooves. The dimensions and shape of the edges to be joined by butt welds shall be such as to permit complete fusion and complete joint penetration.

PW-9.3 Joints Between Materials of Unequal Thickness. Except as provided in PW-9.3.2, a tapered transition section having a length not less than three times the offset between the adjoining surfaces, as shown in Fig. PW-9.1, shall be provided at joints between materials that differ in thickness by more than one-fourth of the thickness of the thinner material or by more than $\frac{1}{8}$ in. (3.2 mm). The transition section may be formed by any process that will provide a uniform taper. The weld may be partly or entirely in the tapered section or adjacent to it as indicated in Fig. PW-9.1.

This paragraph is not intended to apply to joint design specifically provided for elsewhere in this Code or to joints between tubes, between tubes and headers, and between tubes and tubesheets.

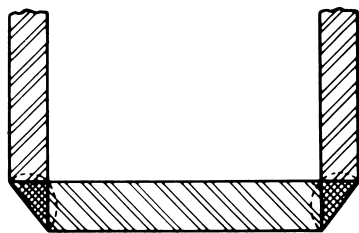


FIG. PW-9.2 PROHIBITED WELDED JOINT

01 PW-9.3.1 Alignment of Shells and Vessels (Including Pipe or Tube Used as a Shell). In longitudinal shell joints, the middle lines of the adjoining thicknesses shall be in alignment within the fabricating tolerances specified in PW-33.

Alternatively, the middle lines of plates of differing thickness may be offset so that the inside or outside diameters of the thinner and thicker portions of the shell form a continuous surface, provided the following conditions are met:

(a) The ratio of the thickness of the thicker plate to the thickness of the thinner plate shall not exceed 2:1; and

(b) The maximum design temperature shall not exceed 750°F.

PW-9.3.2 Circumferential Welds in Tube and Pipe. When components of different diameters or thicknesses are welded together, the transition shall not exceed a slope of 30 deg from the smaller to the larger diameter. The transition may be formed by any process that will provide a uniform taper. Alignment shall meet the provisions of PW-34.

PW-9.4 Prohibited Welded Joints. Corner joints as depicted in Fig. PW-9.2 are prohibited.

PW-10 HEAT TREATMENT

Vessels and vessel parts shall be preheated and postweld heat treated in accordance with the requirements in PW-38 and PW-39.

PW-11 RADIOGRAPHIC AND ULTRASONIC EXAMINATION OF WELDED BUTT JOINTS

PW-11.1 Welded butt joints requiring radiographic and ultrasonic examination are specified in Table PW-

11. Experience has demonstrated that welded butt joints not requiring radiographic and ultrasonic examination by these rules have given safe and reliable service even if they contain imperfections that may be disclosed upon further examination. Any examination and acceptance standards beyond the requirements of this Section are beyond the scope of this Code and shall be a matter of agreement between the Manufacturer and the user.

PW-11.2 Definitions. For use with Table PW-11, the following definitions apply.

butt joint — a joint between two members aligned approximately in the same plane.

circumferential butt weld — includes circumferential welded butt joints in drums, headers, pipes, and tubes, and welded butt joints attaching formed heads to drums, shells, and headers.

longitudinal butt weld — includes longitudinal and spiral welded butt joints in drums, shells, headers, pipes, and tubes; any welded butt joint within a sphere or within a formed or flat head or tube sheet; and welded butt joints attaching insert-nozzles of the type shown in Fig. PW-16.1, sketches (q-1), (q-2), (q-3), and (q-4).

NPS — nominal pipe size.

RT — radiographic examination.

UT — ultrasonic examination.

PW-11.3 For use with Table PW-11, the size and thickness of welded butt joints is defined as the larger and thicker of the two abutting edges after edge preparation.

The geometric unsharpness U_g is defined by the equation

$$U_g = Fd/D$$

where

D = distance from source of radiation to the weld, in. (mm)

d = distance from the source side of the weld to the film, in. (mm)

F = source size; the maximum projected dimension of the radiating source (or effective focal spot) in the plane perpendicular to the distance D from the weld, in. (mm)

U_g = geometric unsharpness, in. (mm)

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TABLE PW-11
REQUIRED RADIOGRAPHIC AND ULTRASONIC EXAMINATION OF WELDED BUTT JOINTS

Pressure Part Service Conditions [Note (1)]				
Butt Weld Type	In Contact With Furnace Gases > 850°F (450°C)		Not In Contact With Furnace Gases > 850°F (450°C)	
	Subject to Furnace Radiant Heat [Note (2)]	Not Subject to Furnace Radiant Heat [Note (2)]	Not Subject to Furnace Radiant Heat [Note (2)]	
	Contains Steam and/or Water		Contains Water	Contains Steam
Longitudinal	RT all sizes and thicknesses	RT all sizes and thicknesses	RT all sizes and thicknesses	RT all sizes and thicknesses
Circumferential welds in drums and shells	RT > NPS 10 (DN 250) or > 1 $\frac{1}{8}$ in. (29 mm) thick	RT > NPS 10 (DN 250) or > 1 $\frac{1}{8}$ in. (29 mm) thick	RT > NPS 10 (DN 250) or > 1 $\frac{1}{8}$ in. (29 mm) thick	RT > NPS 10 (DN 250) or > 1 $\frac{1}{8}$ in. (29 mm) thick
Circumferential welds in pipes, tubes, and headers	RT > NPS 4 (DN 100) or > $\frac{1}{2}$ in. (13 mm) thick	RT > NPS 6 (DN 150) or > $\frac{3}{4}$ in. (19 mm) thick	RT > NPS 10 (DN 250) or > 1 $\frac{1}{8}$ in. (29 mm) thick	RT > NPS 16 (DN 400) or > 1 $\frac{5}{8}$ in. (41 mm) thick

GENERAL NOTES:

- Unless exempted by this table, all longitudinal and circumferential welded butt joints are to be radiographically examined (RT) throughout their entire length. Ultrasonic examination (UT) of the welds shall be performed in lieu of RT when it is impracticable to use a combination of radiographic parameters such that a geometric unsharpness of 0.07 in. (1.8 mm) will not be exceeded. When RT is required for welds in ferritic materials using the electroslag process, UT shall also be performed in addition to RT. When RT is required for welds made in any material using the inertia or continuous drive friction welding processes, UT shall be performed in addition to RT.
- If a grain refining (austenitizing) heat treatment is used for electroslag welds, the UT examination shall be performed after the heat treatment is completed. If an austenitizing heat treatment is not used, the UT examination shall be done after an intermediate postweld heat treatment or after the final postweld heat treatment is completed.
- Radiographic examination shall be performed in accordance with Article 2 of Section V. UT examination shall be performed in accordance with Article 5 of Section V.
- Acceptance criteria for the nondestructive examination performed are PW-51 for RT and PW-52 for UT.
- RT is required when either the size or wall thickness limit is exceeded (i.e., the diameter and thickness limitations apply independently).
- For electric boilers, RT is not required when the maximum allowable working pressure is ≤ 100 psig (690 kPa), and the shell ID is ≤ 16 in. (406 mm) (see PEB-9.1).
- For firetube boilers, RT of longitudinal welded butt joints, made with the addition of filler metal, in furnaces is not required provided a bend test of a sample of the welded joint for each section of the furnace meets the requirements of PW-53. RT of circumferential welded butt joints in furnaces is not required (see PFT-14). For firetube boilers, RT is not required for butt welds in fireboxes and waterlegs provided the construction meets the requirements of PFT-21.2 and PFT-21.3.
- For miniature boilers, RT is not required (see PMB-9).
- RT is not required for the longitudinal weld in ERW products that comply with an acceptable material specification when used for construction within the limitations of PG-9.5.

NOTES:

- Service conditions and pressure part contents are as determined by the designer.
- A weld will not be considered subject to radiant heat from the furnace when in a portion of a pressure part that has five or more rows of tubes between it and the furnace.

PW-13 HEAD-TO-FLANGE REQUIREMENTS

Dished heads, other than hemispherical, concave to pressure to be attached by butt welding, and flanged heads or flanged furnace connections to be fillet welded, shall have a length of flange not less than 1 in. (25 mm) for heads or furnace openings not over 24 in. (610 mm) in external diameter and not less than 1½ in. (38 mm) for heads or furnace openings over 24 in. (610 mm) in diameter.

PW-14 OPENINGS IN OR ADJACENT TO WELDS

Any type of opening that meets the requirements for compensation given in PG-32 through PG-44 may be located in a welded joint.

PW-15 WELDED CONNECTIONS

PW-15.1 Nozzles, other connections, and their compensation may be attached to vessels by arc or gas welding. Sufficient weld and compensation shall be provided on either side of the plane through the center of the opening, parallel to the longitudinal axis of the vessel, to develop the required strength, as prescribed in PG-37, through each load-carrying path, in shear or tension, whichever is applicable.

PW-15.1.1 The stress correction factors in PW-15.2 shall apply to all elements comprising each load-carrying path, except as permitted in PW-15.1.5.

PW-15.1.2 The strength of fillet welds shall be based on one-half the area subjected to shear, computed on the inside diameter of the weld when calculating path number 3, per Fig. PW-16, or the mean diameter of the weld when calculating paths number 1 or 2, per Fig. PW-16, using the weld leg dimension in the direction under consideration.

PW-15.1.3 The strength of groove welds shall be based on one-half the area subjected to shear or tension, as applicable, computed using the minimum weld depth dimension at the line of the load-carrying path in the direction under consideration. The diameter of the weld shall be taken as the inside diameter of the weld when calculating path number 3, per Fig. PW-16, or the mean diameter of the weld when calculating paths number 1 or 2, per Fig. PW-16.

PW-15.1.4 The strength of the nozzle wall shall be based on one-half the area subjected to shear,

computed using the actual nozzle thickness, less corrosion allowance, and the mean diameter of the nozzle wall.

PW-15.1.5 The strength of the nozzle lip [see Fig. PW-16.1(u-1) and (u-2)] shall be based on one-half the area subjected to shear, computed using the actual lip thickness, less corrosion allowance, and the inside diameter of the opening in the vessel at the line of contact with the nozzle lip. The stress correction factor for the nozzle wall in shear in PW-15.2 shall apply.

PW-15.1.6 The following is a guide, listing the load-carrying paths requiring consideration, as applicable to the welded connections shown in Fig. PW-16.1.

PW-15.1.6.1 Sketches (a), (b), (r), (s), (t), (w-3), and (x). Consideration of load-carrying path number 1, per Fig. PW-16(a), is required.

PW-15.1.6.2 Sketches (c), (d), (e-1), (e-2), (f), (g), (h), (u-1), (v-1), (v-2), (w-1), (w-2), (y), and (z). Consideration of load-carrying paths number 1 and 3, per Fig. PW-16(b), is required.

PW-15.1.6.3 Sketches (1), (m), (n), (o), and (p). Consideration of load-carrying paths number 1, 2, and 3, per Fig. PW-16(c), is required.

PW-15.1.6.4 Sketches (k) and (u-2). Consideration of load-carrying paths number 1 and 3, per Fig. PW-16(d), is required.

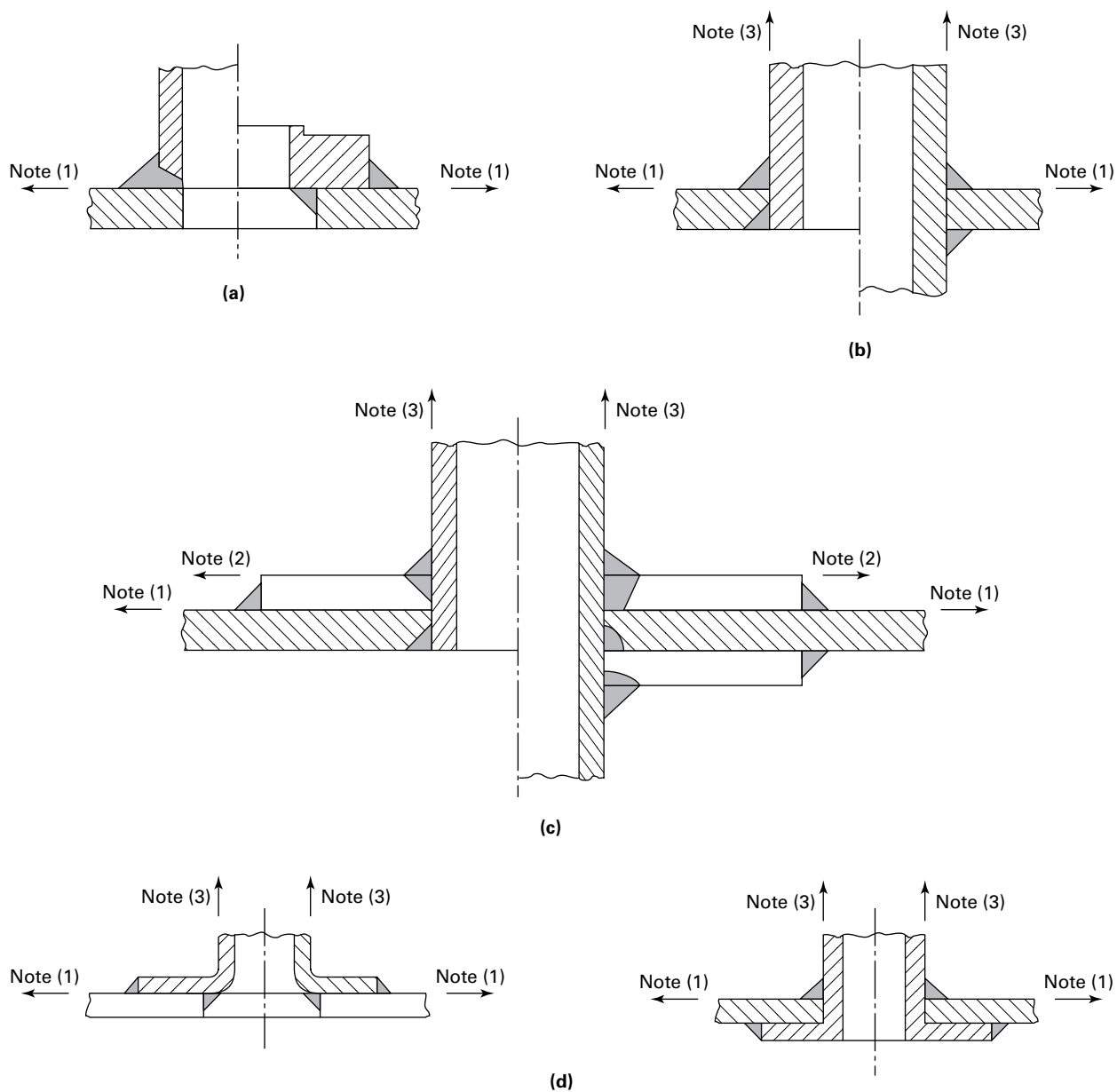
PW-15.1.6.5 Sketches (q-1), (q-2), (q-3) and (q-4). Consideration of the load-carrying paths is not required.

PW-15.2 Stress Values for Weld Metal. The allowable stress values for groove and fillet welds and for shear in nozzle necks in percentages of stress values for the vessel material are as follows:

Nozzle-wall shear	70%
Groove-weld tension	74%
Groove-weld shear	60%
Fillet-weld shear	49%

NOTE: These values are obtained by combining the following factors: 87½% for combined end and side loading, 80% for shear strength, and the applicable joint efficiency factors.

PW-15.3 Compensation plates and saddles of nozzles attached to the outside of a vessel shall be provided with at least one telltale hole (maximum size ¼ in. pipe tap) that may be tapped for a preliminary compressed-air and soapsuds test for tightness of welds that seal off



NOTES:

- (1) Denotes the load-carrying path acting perpendicular to the nozzle center line about the nozzle at the face of the vessel.
- (2) Denotes the load-carrying path acting perpendicular to the nozzle center line about the nozzle at the face of the external pad.
- (3) Denotes the load-carrying path about the nozzle acting parallel to the nozzle center line.

FIG. PW-16 LOAD-CARRYING PATHS IN WELDED NOZZLE ATTACHMENTS

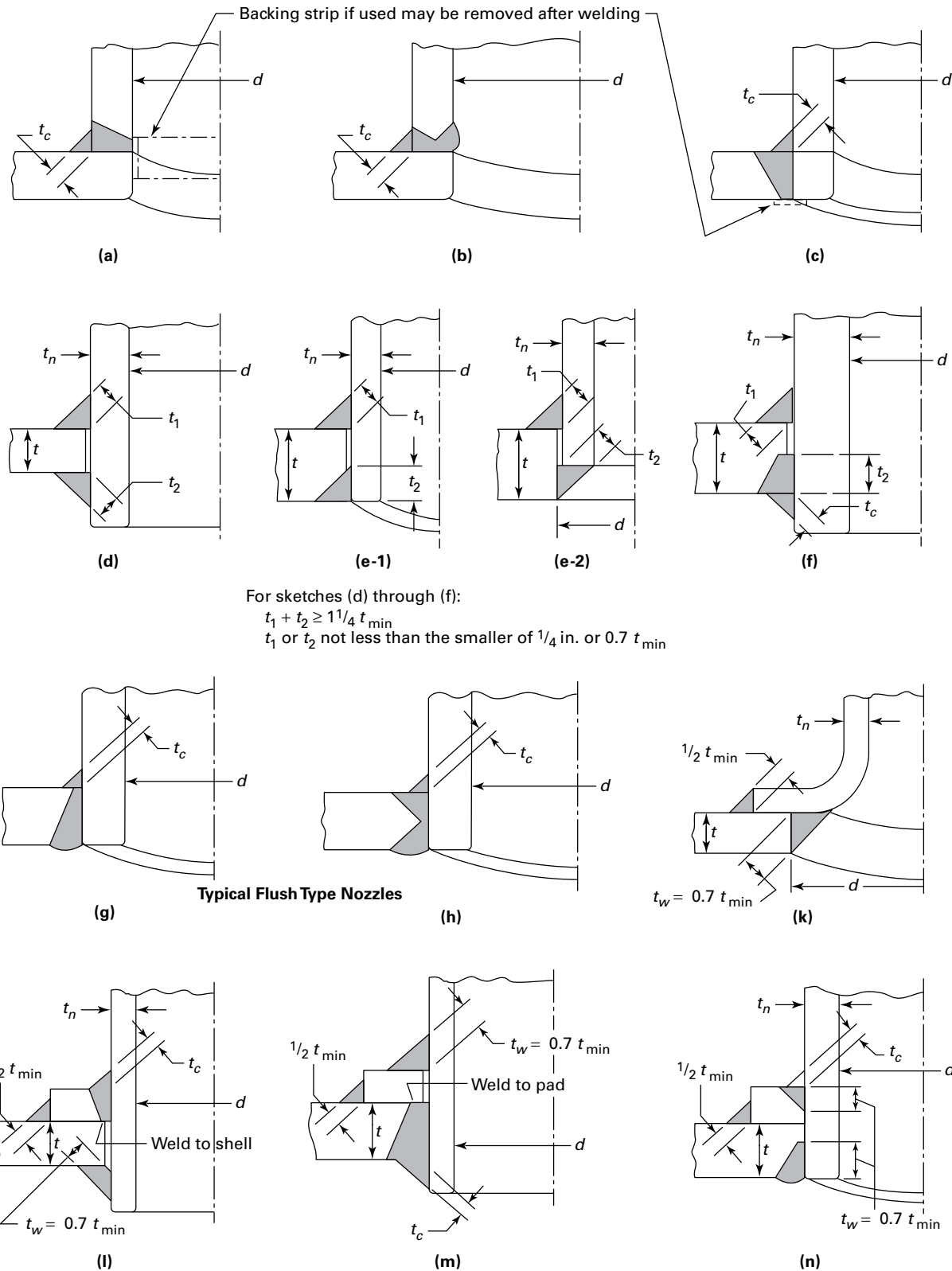


FIG. PW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS

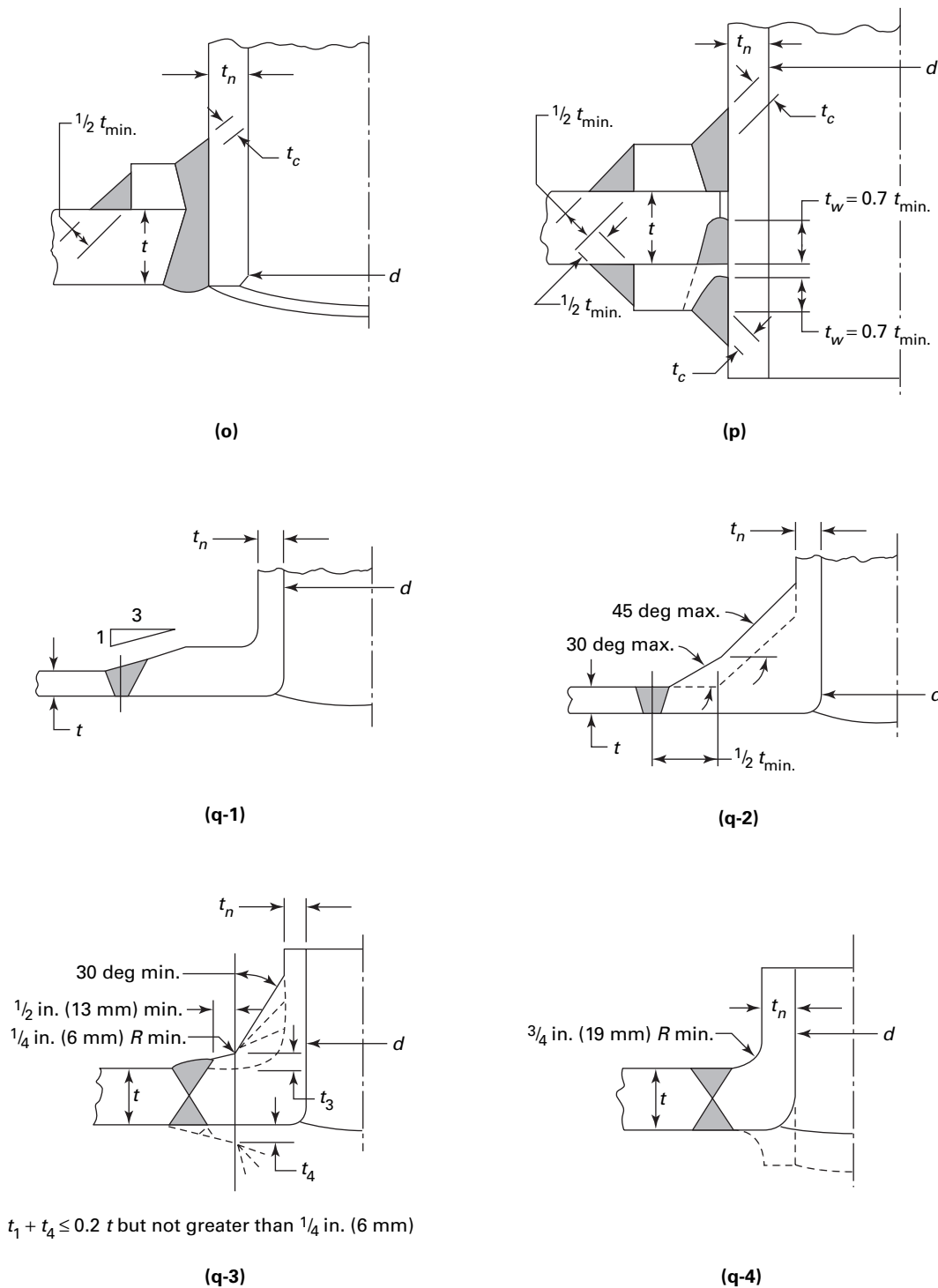
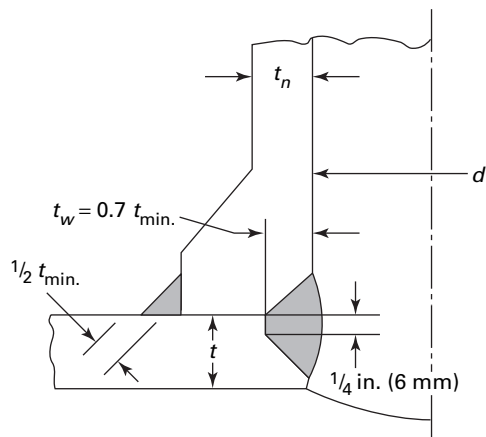
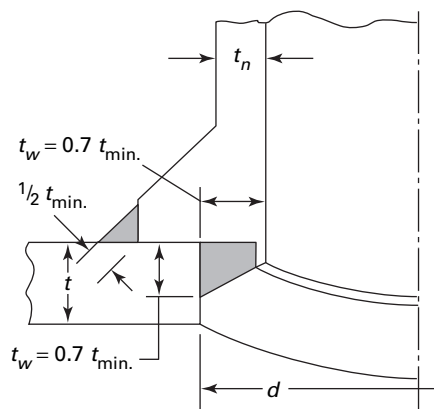


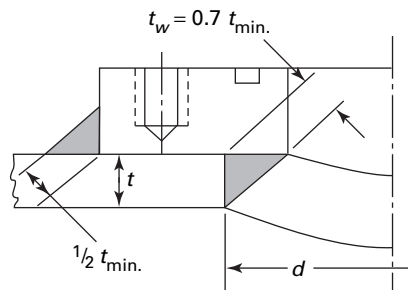
FIG. PW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS (CONT'D)



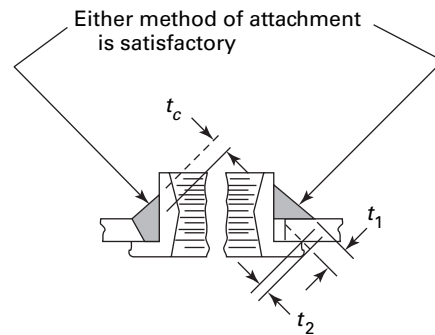
(r)



(s)

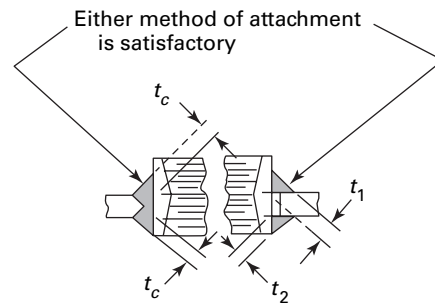


(t)



(u-1)

(u-2)



(v-1)

(v-2)

For sketches (u) and (v):

$$t_1 + t_2 \geq 1\frac{1}{4} t_{\min.}$$

t_1 or t_2 not less than the smaller of $\frac{1}{4}$ in. (6 mm) or $0.7 t_{\min.}$

For sketches (u-2) and (v-2):

For 3 in. (76 mm) pipe and smaller, see exemption in PW-16.4.

FIG. PW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS (CONT'D)

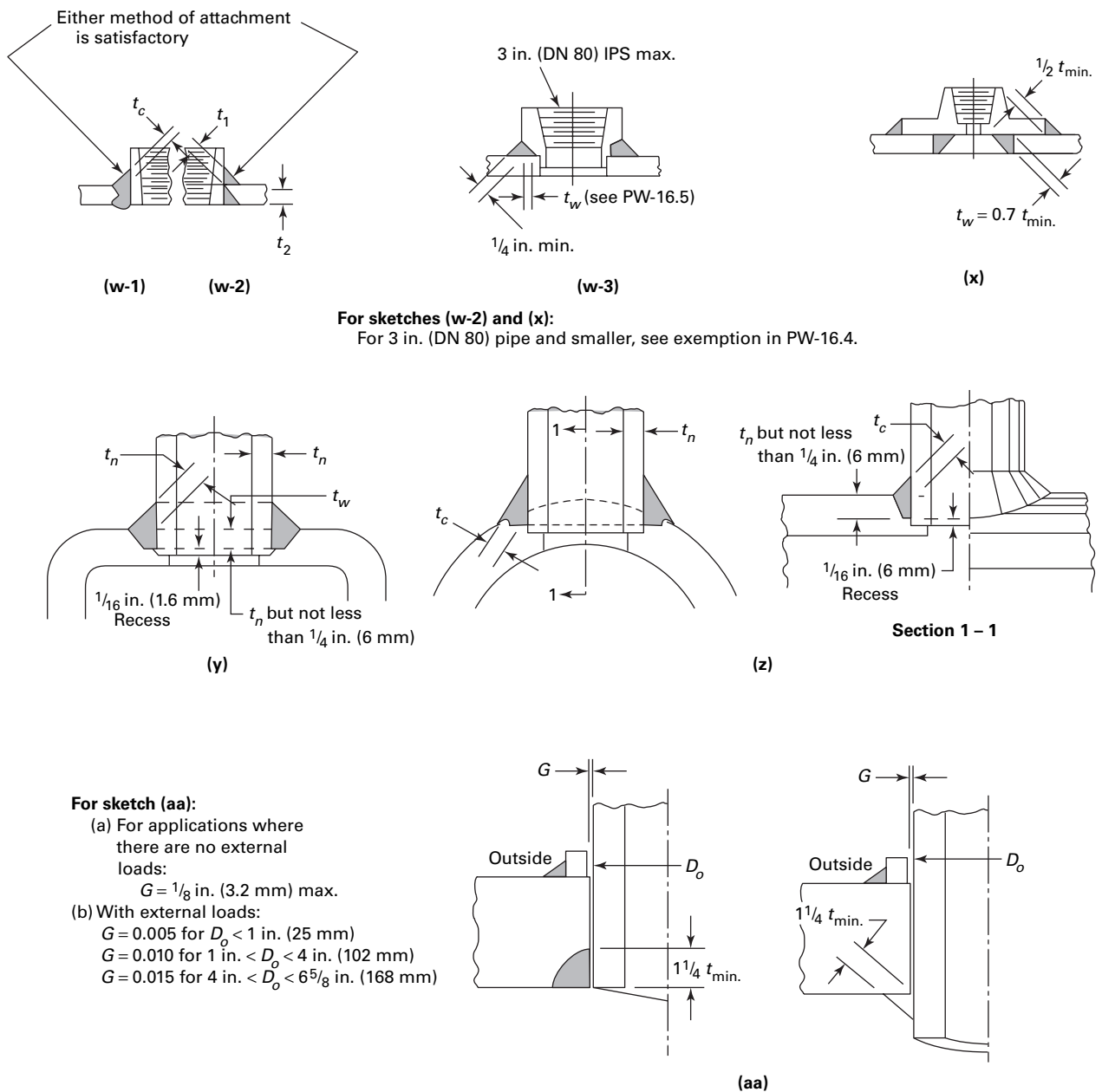
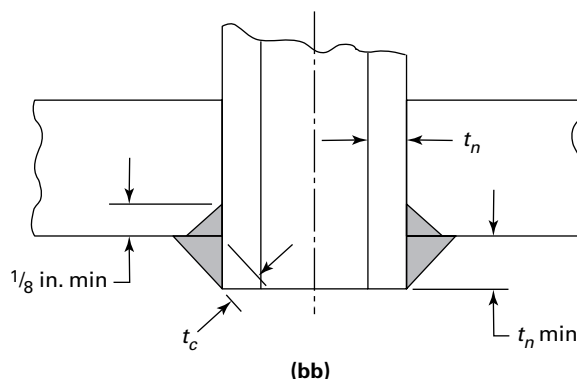


FIG. PW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS (CONT'D)



GENERAL NOTE [sketch (bb)]: NPS 2 max. $t_n \leq 1/4$ in.

FIG. PW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS (CONT'D)

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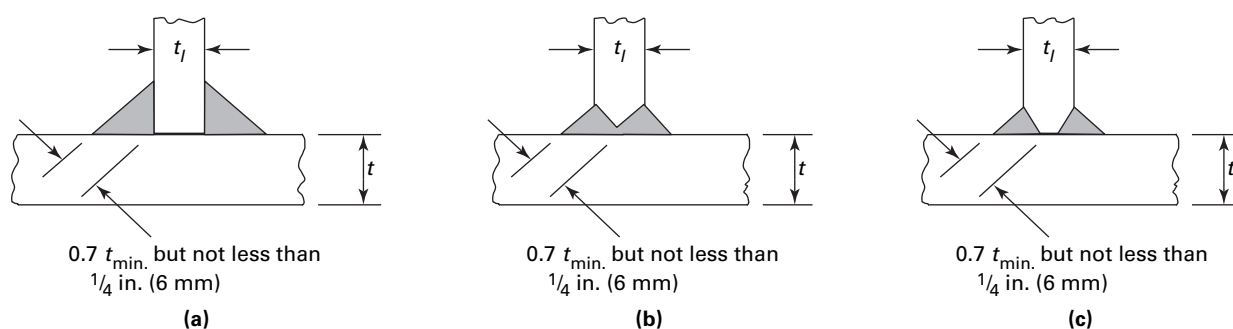


FIG. PW-16.2 SOME ACCEPTABLE FORMS OF WELDS FOR LUGS, HANGERS, AND BRACKETS ON SHELLS, DRUMS, AND HEADERS (See PG-55)

the inside of the vessel. These telltale holes shall be left open when the vessel is in service.

PW-15.4 Figure PW-16.1 illustrates some types of fusion welded connections which are acceptable.

When end faces of nozzle or manhole necks are to remain unwelded in the completed vessel, these end faces shall not be cut by shearing unless at least $1/8$ in. (3.2 mm) of additional metal is removed by any method that will produce a smooth finish.

PW-16 MINIMUM REQUIREMENTS FOR ATTACHMENT WELDS

PW-16.1 General. In addition to the strength calculations required in PG-37, the location and minimum

size of attachment welds for nozzles and other connections shall conform to the requirements in this paragraph.

PW-16.2 Nomenclature. The symbols used in this paragraph and in Fig. PW-16.1 and Fig. PW-16.2 are defined as follows:

- t = thickness of vessel shell or head, in. (mm)
- t_n = thickness of nozzle wall, in. (mm)
- t_w = dimension of partial penetration attachment welds (fillet, single bevel, or single J), measured as shown in Fig. PW-16.1, in. (mm)
- t_c = not less than the smaller of $1/4$ in. (6 mm) or $0.7 t_{min}$ (inside corner welds may be further limited by a lesser length of projection of the nozzle wall beyond the inside face of the vessel wall)

$t_{\min}$ = the smaller of $\frac{3}{4}$ in. (19 mm) or the thickness of either of the weld parts joined by a fillet, single bevel, or single J-weld, in. (mm)

$t_1 + t_2 \geq 1\frac{1}{4} t_{\min}$ measured as shown in Fig. PW-16.1, in., t_1 or t_2 not less than the smaller of $\frac{1}{4}$ in. (6 mm) or $0.7 t_{\min}$

t_l = thickness of lug, hanger, or bracket, as shown in Fig. PW-16.2, in. (mm)

PW-16.3 All welding shall be equivalent to that required under the rules within this Section. Radiographic examination of attachment welds may be omitted except as specifically required in other paragraphs of this Code, and except for inserted-type nozzles similar to those illustrated in Fig. PW-16.1, sketches (q-1), (q-2), (q-3), and (q-4).

PW-16.4 Fittings shown in Fig. PW-16.1, sketches (u-2), (v-2), (w-2), and (x) not exceeding NPS 3 (DN 80) may be attached by welds that are exempt from size requirements other than those specified in PW-15.1.

PW-16.5 Internally threaded fittings not exceeding NPS 3 (DN 80) may be attached by a fillet groove weld from the outside only as shown in Fig. PW-16.1, sketch (w-3). The groove weld t_w shall not be less than the thickness of Schedule 160 pipe (ANSI/ASME B36.10M).

01 PW-16.6 Necks and Tubes Up To and Including NPS 6 Attached From One Side Only.

Necks and tubes not exceeding NPS 6 may be attached from one side only on either the outside or inside of the vessel:

(a) When the neck or tube is attached from the outside only, a welding groove shall be cut into the surface to a depth of not less than t_n on the longitudinal axis of the opening. It is recommended that a recess $\frac{1}{16}$ in. (1.6 mm) deep be provided at the bottom of the groove in which to center the nozzle. The dimension t_w of the attachment weld shall not be less than t_n nor less than $\frac{1}{4}$ in. (6 mm). See Fig. PW-16.1 sketches (y) and (z).

(b) When the neck or tube is attached from the inside only, the depth of welding groove or throat of fillet weld shall be at least equal to $1\frac{1}{4} t_{\min}$. Radial clearance between the vessel hole and nozzle outside diameter at the unwelded side shall not exceed tolerances given in Fig. PW-16.1, sketch (aa). Such attachments shall satisfy the rules for reinforcement of opening except that no material in the nozzle neck shall be counted as reinforcement.

(c) Watertubes may be welded into a tubesheet or header in accordance with the following provisions,

where t_w , t_c , and $t_{\min}$ are as defined in PW-16.2 and illustrated in Fig. PW-16.1, sketch (bb).

(1) The size shall not exceed NPS 2 (DN 50).

(2) The thickness shall not exceed $\frac{1}{4}$ in. (6 mm).

(3) The groove depth t_w shall not be less than $\frac{1}{8}$ in. (3.2 mm) and t_c shall not be less than $\frac{1}{4}$ in. (6 mm) or $0.7 t_{\min}$, whichever is smaller.

(4) The tube shall be welded from the waterside of the boiler.

(5) The application shall be limited to 650°F (343°C) maximum.

PW-19 WELDED-IN STAYS

Welded-in stays may be used in lieu of threading and shall meet the following requirements.

PW-19.1 The stays shall be inserted into countersunk holes through the sheet, except as provided in PW-19.4, and attached by full penetration welds. The area of the weld in shear measured parallel to that portion of the stay extending through the sheet shall be not less than 1.25 times the required cross-sectional area of the stay, but in no case shall the size of the weld be less than $\frac{3}{8}$ in. (10 mm).

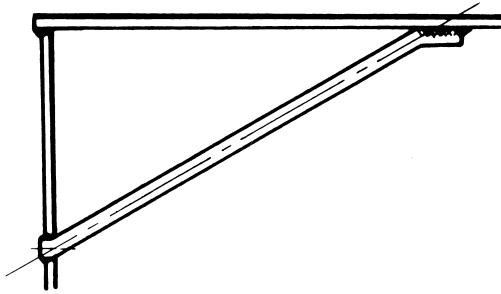
PW-19.2 The ends of the stays shall not be covered by weld metal and the face of the welds shall not be below the outside surface of the plates.

PW-19.3 The ends of stays inserted through the sheet shall not project more than $\frac{3}{8}$ in. (10 mm) beyond surfaces exposed to products of combustion.

PW-19.4 Diagonal stays shall be attached to the inner surface of the shell, but not the head, by fillet welds only. See Fig. PW-19.4(a) and Fig. PW-19.4(b), provided:

PW-19.4.1 Fillet welds shall be not less than $\frac{3}{8}$ in. (10 mm) size and shall continue the full length of each side of the portion of the stay in contact with the shell. The product of the aggregate length of these fillet welds times their throat shall be not less than 1.25 times the required cross-sectional area of the stay. A fillet weld across the end of the stay is optional but shall not be credited in calculating the required area of fillet welds.

PW-19.4.3 The longitudinal center line of the stay, projected if necessary, shall intersect the inner surface of the plate to which the stay is attached within the outer boundaries of the attaching welds, also projected if necessary.



GENERAL NOTE: A round bar or a round bar with a forged palm

FIG. PW-19.4(a) SOME ACCEPTABLE TYPES OF DIAGONAL BRACES FOR INSTALLATION BY WELDING

PW-19.5 The pitch of stays attached by welding to flat surfaces shall comply with the requirements of PFT-27.

PW-19.6 The welding shall be done in such a manner that excessive weld deposits do not project through the surface of the plate at the root of the weld.

PW-19.7 The welding shall be postweld heat treated in accordance with PW-39.

PW-19.8 Telltale holes are not required in staybolts attached by welding.

FABRICATION

PW-26 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of boilers and parts thereof that are fabricated by welding and shall be used in conjunction with the general requirements for fabrication in Part PG, as well as with the specific requirements for fabrication in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PW-27 WELDING PROCESSES

The welding processes that may be used under this Part shall meet all the test requirements of Section IX and are restricted to the following.

PW-27.1 The following welding processes may be used for any Section I construction: shielded metal arc,

submerged arc, gas metal arc, flux cored arc, gas tungsten arc, plasma arc, atomic hydrogen arc, oxyhydrogen, oxyacetylene, laser beam, electron beam, flash, induction, resistance, pressure thermit, pressure gas, and inertia and continuous drive friction welding.

PW-27.2 Arc stud welding and resistance stud welding may be used for nonpressure-bearing attachments having a load- or non-load-carrying function. Stud size shall be limited to 1 in. (25 mm) diameter maximum for round studs or an equivalent cross-sectional area for studs with other shapes. For load-carrying attachments, the requirements of PW-28.6 shall be met prior to the start of production welding, and the postweld heat treatment requirements of PW-39 shall also be complied with.

PW-27.3 The electroslag welding process may be used for butt welds only in austenitic stainless steels of types listed in PW-5.3 and ferritic steels, provided the requirements of PW-11.2.2 and PW-39.7 are satisfied.

PW-27.4 Definitions are given in Section IX, which include variations of these processes.

PW-28 WELDING QUALIFICATION AND WELD RECORDS

PW-28.1 Requirements for Qualification of Welding Procedures, Welders, and Welding Operators

PW-28.1.1 The Welding Procedure Specifications, the welders, and the welding operators used in welding pressure parts and in joining load-carrying nonpressure parts, such as all permanent or temporary clips and lugs, to pressure parts shall be qualified in accordance with Section IX.

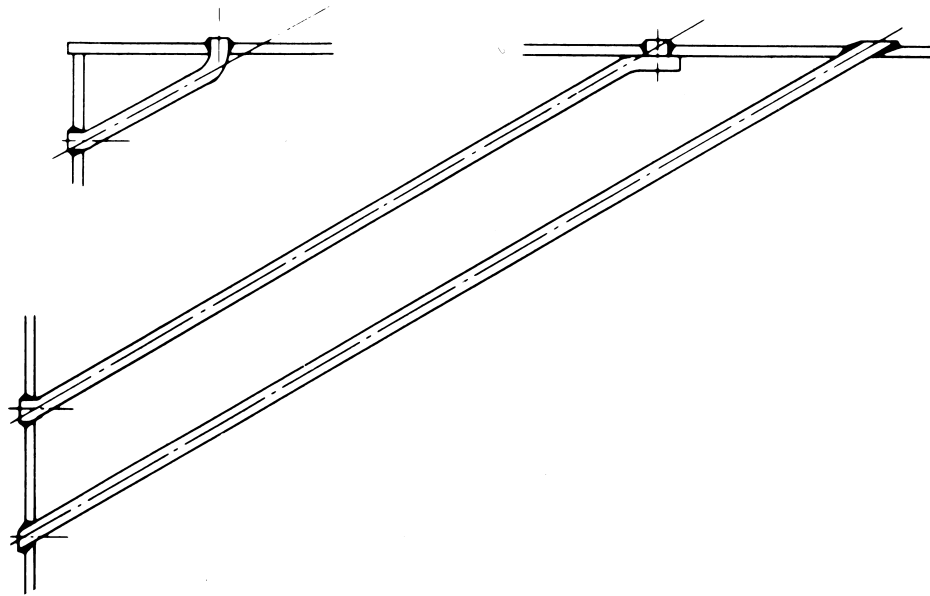


FIG. PW-19.4(b) UNACCEPTABLE TYPES OF DIAGONAL BRACES FOR INSTALLATION BY WELDING

PW-28.1.2 Except as provided in (a) and (b) below, the Welding Procedure Specification, the welders and the welding operators used in welding nonpressure-bearing attachments which have essentially no load-carrying function (such as extended heat transfer surfaces, insulation support pins, etc.) to pressure parts shall be qualified in accordance with Section IX.

(a) When the welding process is automatic, welding procedure and performance qualification testing is not required.

(b) When the material used for the nonpressure part makes the mechanical test requirements for procedure qualification and performance qualifications impracticable (i.e., insufficient material ductility), a weld test coupon may be evaluated using the macro-examination method for both groove and fillet welds. The test coupon may be of production configuration and shall be of sufficient length to contain a specimen for macro-examination. Heat treatment shall be considered a nonessential variable. The weldable quality of the nonpressure part materials shall be verified by the macro-examination of a single cross-section of the weld. Visual examination of the weld metal and heat-affected zone of both the pressure part and nonpressure part material shall show complete fusion and freedom from cracks.

PW-28.1.3 Welding of all test coupons shall be conducted by the Manufacturer. Testing of all test coupons shall be the responsibility of the Manufacturer.

Qualification of a welding procedure, a welder, or a welding operator by one Manufacturer shall not qualify that procedure, welder, or the welding operator for any other Manufacturer except as provided in QW-201 and QW-300 of Section IX and PW-28.5.

PW-28.2 No production work shall be undertaken until the procedures, the welders, and the welding operators have been qualified, except that performance qualification by radiography, in conformance with Section IX, QW-304 for welders or QW-305 for welding operators, may be performed within the first 3 ft (0.9 m) of the first production weld.

PW-28.4 The Manufacturer shall maintain a record of the welding procedures, welders, and welding operators employed, showing the date, results of the tests, and the identification mark assigned to each welder. These records shall be certified by the Manufacturer and be accessible to the Authorized Inspector.

PW-28.4.1 The Manufacturer shall also establish a procedure whereby all welded joints, except as permitted in PW-28.4.2 and PW-28.4.3, can be identified as to the welder or welding operator who made them. This procedure shall use one or more of the following methods and be acceptable to the Authorized Inspector. The welder or welding operator may stamp his identification mark on or adjacent to all welded joints made by him, or he may stamp on or adjacent to a continuous

weld or a series of similar joints made by him at intervals of not greater than 3 ft (0.9 m), or, in lieu of stamping, the Manufacturer may keep a record of welded joints and the welders or welding operators used in making the joints.

PW-28.4.2 When making multiple load-carrying or non-load-carrying structural attachment welds on pressure parts, the Manufacturer need not identify the welder or welding operator that welded each individual joint provided:

(1) the Manufacturer's Quality Control System includes a procedure whereby the identity of the welders or welding operators that made such welds on each pressure part will be maintained so that the Inspector can verify that the welders or welding operators were all properly qualified; and

(2) the welds are all the same type and configuration and are welded with the same welding procedure specification.

PW-28.4.3 Identification of welders or welding operators making tack welds that become part of a final pressure-retaining weld or structural attachment weld is not required provided the Quality Control System of the Manufacturer includes a procedure to permit the Inspector to verify that such tack welds were made by qualified welders or welding operators.

PW-28.5 To avoid duplication of qualification tests, it is recommended that procedures, welders, and welding operators qualified as required above be acceptable for any similar welding work on piping using the same procedure (see PW-1.2).

PW-28.6 In the case where stud welding is used to attach load-carrying studs, a production stud weld test of the procedure and welding operator shall be performed on a separate test plate or tube prior to the start of production welding on the first work piece. This weld test shall consist of five studs, welded and subjected to either the bend or torque stud weld testing described in Section IX.

PW-29 BASE METAL PREPARATION

PW-29.1 The preparation of joints prior to welding may involve any of the conventional methods in use such as machining, thermal cutting, chipping, grinding, or combinations of these.

PW-29.2 Where thermal cutting is used, the effect on the mechanical and metallurgical properties of the base metal shall be taken into consideration.

PW-29.3 The method of base metal preparation used shall leave the welding groove with reasonably smooth surfaces and free from deep notches, striations, or irregularities. The surfaces for welding shall be free of all scale, rust, oil, grease, or other foreign materials.

PW-29.4 Cast surfaces to be welded shall be machined, chipped, or ground where necessary to remove foundry scale and to expose sound metal.

PW-31 ASSEMBLY

PW-31.1 Parts that are being welded shall be fitted, aligned, and retained in position during the welding operation within the tolerance specified in PW-33.

PW-31.2 Bars, jacks, clamps, tack welds, or other appropriate means may be used to hold the edges of the parts to be welded in alignment.

PW-31.3 Tack welds used to secure alignment shall either be removed completely when they have served their purpose or their stopping and starting ends shall be properly prepared by grinding or other suitable means so that they may be satisfactorily incorporated into the final weld. Tack welds, whether removed or left in place, shall be made using a fillet weld or butt weld procedure qualified in accordance with Section IX. Tack welds to be left in place shall be made by welders qualified in accordance with Section IX and shall be examined visually for defects and, if found to be defective, shall be removed.

PW-31.4 When joining two parts by the inertia and continuous drive friction welding processes, one of the two parts must be held in a fixed position and the other part rotated. The two faces to be joined must be essentially symmetrical with respect to the axis of rotation. Some of the basic types of applicable joints are solid round-to-solid round, tube-to-tube, solid round-to-tube, solid round-to-plate, and tube-to-plate.

PW-33 ALIGNMENT TOLERANCE, SHELLS AND VESSELS (INCLUDING PIPE OR TUBE USED AS A SHELL)

PW-33.1 Alignment of sections at edges to be butt welded shall be such that the maximum offset is not

greater than the applicable amount as listed in Table PW-33, where t is the nominal thickness of the thinner section at the joint.

PW-33.2 Joints in spherical vessels and within heads and joints between cylindrical shells and hemispherical heads shall meet the requirements in PW-33.1 above for longitudinal joints in cylindrical shells.

PW-33.3 Any offset within the allowable tolerance provided above shall be faired at a 3 to 1 taper over the width of the finished weld, or if necessary, by adding additional weld metal beyond what would otherwise be the edge of the weld.

TABLE PW-33
ALIGNMENT TOLERANCE OF SECTIONS
TO BE BUTTWELDED

Section Thickness, in. (mm)	Direction of Joints in Cylindrical Shells	
	Longitudinal in. (mm)	Circumferential in. (mm)
Up to $\frac{1}{2}$ (13), incl.	$\frac{1}{4}t$	$\frac{1}{4}t$
Over $\frac{1}{2}$ (13) to $\frac{3}{4}$ (19), incl.	$\frac{1}{8}$ (3.2)	$\frac{1}{4}t$
Over $\frac{3}{4}$ (19) to $1\frac{1}{2}$ (38), incl.	$\frac{1}{8}$ (3.2)	$\frac{3}{16}$ (4.8)
Over $1\frac{1}{2}$ (38) to 2 (51), incl.	$\frac{1}{8}$ (3.2)	$\frac{1}{8}t$
Over 2 (51)	Lesser of $\frac{1}{16}t$ or $\frac{3}{8}$ (10)	Lesser of $\frac{1}{8}t$ or $\frac{3}{4}$ (19)

PW-34 ALIGNMENT, TUBE AND PIPE

PW-34.1 When tubes or pipes are welded together, the alignment shall be such that the inside surfaces provide for complete weld penetration. The weld shall meet the reinforcement requirements of PW-35.

PW-35 FINISHED LONGITUDINAL AND CIRCUMFERENTIAL JOINTS

PW-35.1 Butt welds shall have complete joint penetration. To assure that the weld grooves are completely filled so that the surface of the weld metal at any point is not below the surface of the adjoining base materials, weld metal may be added as reinforcement on each face of the weld. The thickness of the weld reinforcement on each face shall not exceed the following:

Nominal Thickness, in. (mm)	Maximum Reinforcement, in. (mm)	
	Circumferential Joints in Pipe and Tubing	Other Welds
Up to $\frac{1}{8}$ (3.2)	$\frac{3}{32}$ (2.4)	$\frac{3}{32}$ (2.4)
Over $\frac{1}{8}$ (3.2) to $\frac{3}{16}$ (4.8), incl.	$\frac{1}{8}$ (3.2)	$\frac{3}{32}$ (2.4)
Over $\frac{3}{16}$ (4.8) to $\frac{1}{2}$ (13), incl.	$\frac{5}{32}$ (4.0)	$\frac{3}{32}$ (2.4)
Over $\frac{1}{2}$ (13) to 1 (25), incl.	$\frac{3}{16}$ (3.8)	$\frac{3}{32}$ (2.4)
Over 1 (25) to 2 (51), incl.	$\frac{1}{4}$ (6.4)	$\frac{1}{8}$ (3.2)
Over 2 (51) to 3 (76), incl.	[Note (1)]	$\frac{5}{32}$ (4.0)
Over 3 (76) to 4 (102), incl.	[Note (1)]	$\frac{7}{32}$ (5.6)
Over 4 (102) to 5 (127), incl.	[Note (1)]	$\frac{1}{4}$ (6.4)
Over 5 (127)	[Note (1)]	$\frac{5}{16}$ (8.0)

NOTE:

(1) The greater of $\frac{1}{4}$ in. (6 mm) or $\frac{1}{8}$ times the width of the weld in inches (mm).

As-welded surfaces are permitted; however, the surface of the welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys

to avoid stress raisers. Undercuts shall not exceed $\frac{1}{32}$ in. (0.8 mm) or 10% of the wall thickness, whichever is less, and shall not encroach on the required section thickness. The surfaces of the finished weld shall be suitable to permit proper interpretation of radiographic and other required nondestructive examinations. If there is a question regarding the surface condition of the weld when interpreting radiographic film, the film shall be compared to the actual weld surface for determination of acceptability.

PW-35.2 The weld reinforcement need not be removed except to the extent necessary to meet the thickness requirements in PW-35.1.

PW-35.3 Backing strips used at longitudinal welded joints shall be removed. Inside backing rings may remain at circumferential joints of cylinders provided they meet the requirements of PW-41.

PW-35.4 The welded joint between two members joined by the inertia and continuous drive friction welding processes shall be full penetration weld. Visual examination of the as-welded flash roll of each weld shall be made as an in-process check. The weld upset shall meet the specified amount with $\pm 10\%$. The flash shall be removed to sound metal.

PW-36 MISCELLANEOUS WELDING REQUIREMENTS

PW-36.1 Before applying weld metal on the second side to be welded, the root of double-welded butt joints shall be prepared by suitable methods such as chipping, grinding, or thermal gouging, so as to secure sound metal at the base of weld metal deposited on the face side, except for those processes of welding by which

proper fusion and penetration are otherwise obtained and by which the root of the weld remains free from impurities.

PW-36.2 Fillet Welds. In making fillet welds, the weld metal shall be deposited in such a way as to secure adequate penetration into the base metal at the root of the weld. Fillet weld contours shall conform to the requirements in Section IX and the surface of such welds shall be free from coarse ripples or grooves, and shall merge smoothly with the surfaces joined.

PW-38 PREHEATING

PW-38.1 The need for and the temperature of preheat are dependent upon a number of factors such as chemical analysis, degree of restraint of the parts being joined, elevated temperature mechanical properties, and material thicknesses. Some practices used for preheating are described in Appendix A-100 as a general guide for the materials listed by P-Numbers of Section IX. It is cautioned that the preheating suggested in A-100 does not necessarily ensure satisfactory completion of the welded joint and that the requirements for individual materials within the P-Number listing may have preheating more or less restrictive than this general guide. The welding procedure specification for the material being welded shall specify the minimum preheating requirements described in the welding procedure qualification requirements of Section IX.

PW-38.2 Preheat for welding or thermal cutting may be applied by any method that does not harm the base material or any weld metal already applied, or that does not introduce into the welding area foreign material that is harmful to the weld.

PW-39 REQUIREMENTS FOR POSTWELD HEAT TREATMENT

The rules in the following paragraphs apply specifically to the fabrication of the boiler proper and parts thereof and do not apply to the external piping as defined in the Preamble.

- 01 **PW-39.1** Before applying the detailed requirements and exemptions in these paragraphs, satisfactory weld procedure qualifications of the procedures to be used shall be performed in accordance with all the essential variables of Section IX including conditions of postweld heat treatment or lack of postweld heat treatment and including other restrictions listed below. Except as otherwise specifically provided in PFT-29, PMB-9, PW-

40.2, PW-40.3, and in the notes within Table PW-39, all welded pressure parts of power boilers shall be given a postweld heat treatment at a temperature not less than that specified in Table PW-39. The materials in Table PW-39 are listed in accordance with the materials P-Number grouping of QW-420 of Section IX.

PW-39.2 When pressure parts of two different P-Number groups are joined by welding, the postweld heat treatment shall be that specified in Table PW-39 and applicable notes for the material requiring the higher postweld heat treatment temperature, except as noted in PW-39.2.1. When nonpressure parts are welded to pressure parts, the postweld heat treatment temperature of the pressure parts shall control.

PW-39.2.1 Fillet welds, partial penetration welds, and full penetration welds through the tube or pipe thickness, attaching P-No. 5A tubes and pipe to headers of lower P-Number material, may be postweld heat treated at the temperature specified in Table PW-39 for the lower P-Number material provided the tubes or pipe comply with all the following conditions:

- (1) a maximum specified chromium content of 3.0%;
- (2) a maximum size of NPS 4 (DN 100);
- (3) a maximum thickness of $\frac{1}{2}$ in. (13 mm);
- (4) a maximum specified carbon content of not more than 0.15%.

PW-39.3 In the procedures that follow, the volume of metal required to be heated, to meet or exceed the minimum post weld heat treatment temperatures listed in Table PW-39, is defined as the soak band. As a minimum, the soak band shall contain the weld and a portion of the base metal on each side of the weld being heat treated, including the weld heat affected zones. The width of each portion of base metal to be included in the soak band shall be equal to the lesser of the vessel or shell thickness, or 2 in. (51 mm). A greater amount of base material, on either or both sides of the weld, may also be heated to permit temperature gradient control.

The weldment shall be heated slowly to the temperature specified in Table PW-39 and held for the specified time, and shall be allowed to cool slowly in a still atmosphere to a temperature not exceeding 800°F (427°C). Several weldments of varied thickness may be postweld heat treated in the same furnace at the same time.

The term nominal thickness in Table PW-39 is the thickness of the weld, pressure retaining material, or the thinner of the sections being joined, whichever is least. For fillet welds, the nominal thickness is the

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TABLE PW-39
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 1 Group No. 1,2,3	1,100 (593)	1 hr/in. (1 hr/25 mm), 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (51 mm)	2 hr plus 15 min for each additional inch over 2 in. (51 mm)

NOTES:

- (1) Postweld heat treatment is not mandatory for P-No. 1 materials under the following conditions:
- (a) for circumferential butt welds in pipe, tubes, or headers when the pipe, tubes, or headers comply with a nominal wall thickness of $\frac{3}{4}$ in. (19 mm) or less at the joint
 - (b) for fillet welds used on slip-on and socket welding flanges and fittings conforming to the rules of PW-41, when the following conditions are met:
 - (1) a fillet weld throat thickness of $\frac{1}{2}$ in. (13 mm) or less, regardless of base metal thickness
 - (2) a minimum preheat of 200°F (93°C) when the thickness of a pressure part at the weld exceeds $\frac{3}{4}$ in. (19 mm)
 - (c) for fillet welds attaching nonpressure parts to pressure parts that have a throat thickness of $\frac{1}{2}$ in. (13 mm) or less, provided preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of the pressure part exceeds $\frac{3}{4}$ in. (19 mm)
 - (d) for welds used to attach extended heat absorbing surface to tubes and insulation attachment pins to pressure parts
 - (e) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of $\frac{3}{8}$ in. (10 mm) or less, and preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of either part exceeds $\frac{3}{4}$ in. (19 mm)
 - (f) for studs welded to pressure parts for purposes not included in (d) above, provided preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of the pressure part exceeds $\frac{3}{4}$ in. (19 mm)
 - (g) for tube-to-tubesheet welded attachment of P-No. 1, Group Nos. 1 and 2 material in firetube boilers in accordance with Fig. PFT-12.1 sketches (f) and (g), if the depth of the weld groove or preparation does not exceed 0.375 in. (10 mm), provided a minimum preheat of 200°F (93°C) is applied when the tubesheet thickness exceeds $\frac{3}{4}$ in. (19 mm)
 - (h) for fillet welds attaching connections to a vessel, provided that all of the following conditions are met:
 - (1) The diameter of the finished opening (diameter d in Figs. PG-36 and PW-16.1) does not exceed that allowed in PG-32.1.2 or 2 in. (51 mm), whichever is less.
 - (2) the throat thickness does not exceed $\frac{3}{8}$ in. (10 mm)
 - (3) preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of either part exceeds $\frac{3}{4}$ in. (19 mm)
 - (4) the connections are not placed in the vessel such as to form ligaments, the efficiency of which would affect the vessel thickness.
 - (i) for combination groove and fillet welds attaching nonpressure parts to pressure parts, with a weld thickness of $\frac{1}{2}$ in. (13 mm) or less, provided preheat to a minimum of 200°F (93°C) is applied when the thickness of the pressure part exceeds $\frac{3}{4}$ in. (19 mm)
- (2) When it is impractical to postweld heat treat at the temperature specified in this Table, it is permissible to carry out the postweld heat treatment at lower temperatures for longer periods of time in accordance with Table PW-39.1.
- (3) For all P-No. 1 Group No. 1 materials, and for P-No. 1 Group No. 2 materials having a maximum actual carbon content of 0.30%, the postweld heat treatment requirement of PWT 11.2 for tubes welded to tubular manifolds or headers is not mandatory when all of the following conditions are met:
- (a) the tubes do not exceed 2 in. (51 mm) O.D.
 - (b) the header does not exceed NPS 8 (DN 200)
 - (c) the header thickness does not exceed $\frac{1}{2}$ in. (13 mm)
 - (d) a minimum preheat of 200°F (93°C) is applied

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 3 Group No. 1,2,3	1,100 (593)	1 hr/in. (1 hr/25 mm), 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (51 mm)	2 hr plus 15 min for each additional inch over 2 in. (51 mm)

NOTES:

- (1) Except for P-No. 3 Group No. 3, postweld heat treatment of P-No. 3 materials is not mandatory under the following conditions (postweld heat treatment is mandatory for P-No. 3 Group No. 3 materials for all thicknesses):
- (a) for circumferential butt welds in pipe, tubes, or headers where the pipe, tubes, or headers comply with both a nominal wall thickness of $\frac{5}{8}$ in. (16 mm) or less, and a specified maximum carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25%
 - (b) for fillet welds used on socket welding fittings conforming to the rules of PW-41, when the following conditions are met:
 - (1) a fillet weld throat thickness of $\frac{1}{2}$ in. (13 mm) or less, regardless of base metal thickness
 - (2) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25%
 - (3) a minimum preheat of 200°F (93°C) when the thickness of a pressure part at the weld exceeds $\frac{5}{8}$ in. (16 mm)
 - (c) for fillet welds with a throat thickness of $\frac{1}{2}$ in. (13 mm) or less and combination groove and fillet welds with a weld thickness of $\frac{1}{2}$ in. (13 mm) or less attaching nonpressure parts having a specified maximum carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25% provided preheat to a minimum temperature of 200°F (93°C) is applied when the pressure part exceeds $\frac{5}{8}$ in. (16 mm)
 - (d) for welds used to attach extended heat-absorbing surface to tubes and insulation attachment pins to pressure parts
 - (e) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of $\frac{3}{8}$ in. (10 mm) or less, and preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of either part exceeds $\frac{5}{8}$ in. (16 mm)
 - (f) postweld heat treatment is not mandatory for studs welded to pressure parts for purposes not included in (d) above and which have a specified maximum carbon content of not more than 0.25% (SA material specification carbon content, except when further limited by Purchaser to a value within the specification limits), provided a preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of the pressure part exceeds $\frac{5}{8}$ in. (16 mm)
 - (g) for fillet welds attaching connections to a vessel, provided that all of the following conditions are met:
 - (1) the diameter of the finished opening (diameter d in Figs. PG-36 and PW-16.1) does not exceed that allowed in PG-32.1.2 or 2 in. (51 mm), whichever is less.
 - (2) the throat thickness does not exceed $\frac{3}{8}$ in. (10 mm)
 - (3) preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of either part exceeds $\frac{5}{8}$ in. (16 mm)
 - (4) the connections are not placed in the vessel such as to form ligaments, the efficiency of which would affect the vessel thickness.
 - (5) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25%.
- (2) When it is impractical to postweld heat treat at the temperature specified in this Table, it is permissible to carry out the postweld heat treatment at lower temperatures for longer periods of time in accordance with Table PW-39.1.
- (3) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 4 Group No. 1,2	1,100 (593)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	5 hr plus 15 min for each additional inch over 5 in. (127 mm)

NOTES:

- (1) Postweld heat treatment is not mandatory for P-No. 4 materials under the following conditions:
- (a) for circumferential butt welds in pipe or tubes where the pipe or tubes comply with all the following conditions:
 - (1) a maximum size of NPS 4 (DN 100)
 - (2) a maximum thickness of $\frac{5}{8}$ in. (16 mm)
 - (3) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
 - (4) a minimum preheat of 250°F (121°C). This minimum preheat is not required for SA-213 Grade T11 tube materials with a maximum outside diameter of 1.5 in. (38 mm) and a maximum thickness of 0.165 in. (4.2 mm) when butt welded using a multipass GTAW process.
 - (b) for fillet welds used on socket welding fittings conforming to the rules of PW-41, when the following conditions are met:
 - (1) a fillet weld throat thickness of $\frac{1}{2}$ in. (13 mm) or less, regardless of base metal thickness
 - (2) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
 - (3) a minimum preheat of 250°F (121°C)
 - (c) for pipe and tube materials meeting the requirements of (a)(1), (a)(2), and (a)(3) above and having fillet welds attaching nonpressure parts to them, provided the fillet weld has a throat thickness of $\frac{1}{2}$ in. (13 mm) or less and the material is preheated to 250°F (121°C) minimum; or combination groove and fillet welds attaching nonpressure parts to pressure parts, with a weld thickness of $\frac{1}{2}$ in. (13 mm) or less, provided the material is preheated to a minimum of 250°F (121°C); or heat-absorbing surfaces and non-load-carrying studs attached to them, provided the material is preheated to 250°F (121°C) minimum. A lower preheating temperature may be used, provided specifically controlled procedures necessary to produce sound joints are used. Such procedures shall include but shall not be limited to the following:
 - (1) The throat thickness of fillet welds shall be $\frac{1}{2}$ in. (13 mm) or less.
 - (2) The maximum continuous length of fillet welds shall be not over 4 in. (102 mm)
 - (3) Electrodes or filler metal shall be dry and shall provide a low-hydrogen weld deposit. Chromemoly filler metals shall have a maximum specified chromium content of not more than 2.50% and a maximum specified carbon content of not more than 0.05%
 - (4) The thickness of the test plate used in making the welding procedure qualification of Section IX shall not be less than that of the material to be welded.
 - (d) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of $\frac{3}{8}$ in. (10 mm) or less, and preheat to a minimum temperature of 250°F (121°C) is applied when the thickness of either part exceeds $\frac{5}{8}$ in. (16 mm)
- (2) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 5A Group No. 1 and P-No. 5B Group No. 1	1,250 (677)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	5 hr plus 15 min for each additional inch over 5 in. (127 mm)
P-No. 5B Group No. 2	1,300 (704)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	5 hr plus 15 min for each additional inch over 5 in. (127 mm)

NOTES:

- (1) Except for P-No. 5B Group No. 2 materials, postweld heat treatment is not mandatory under the following conditions:
- (a) for circumferential butt welds in pipe or tubes where the pipe or tubes comply with all of the following conditions:
 - (1) a maximum specified chromium content of 3.0%
 - (2) a maximum size of NPS 4 (DN 100)
 - (3) a maximum thickness of $\frac{5}{8}$ in. (16 mm)
 - (4) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
 - (5) a minimum preheat of 300°F (149°C)
 - (b) for fillet welds used on socket welding fittings conforming to the rules of PW-41, when the following conditions are met:
 - (1) a maximum specified chromium content of 3.0%
 - (2) a fillet weld throat thickness of $\frac{1}{2}$ in. (13 mm) or less, regardless of base metal thickness
 - (3) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
 - (4) a minimum preheat of 300°F (149°C)
 - (c) for pipe and tube materials meeting the requirements of (a)(1), (a)(2), (a)(3), and (a)(4) above having fillet welds attaching nonpressure parts to them, provided the fillet weld has a throat thickness of $\frac{1}{2}$ in. (13 mm) or less and the material is preheated to 300°F (149°C) minimum; or combination groove and fillet welds attaching nonpressure parts to pressure parts, with a weld thickness of $\frac{1}{2}$ in. (13 mm) or less, and the material is preheated to a minimum of 300°F (149°C); or heat-absorbing surfaces and non-load-carrying studs attached to them, provided the material is preheated to 300°F (149°C) minimum. A lower preheating temperature may be used, provided specifically controlled procedures necessary to produce sound joints are used. Such procedures shall include but shall not be limited to the following:
 - (1) The maximum throat thickness of fillet welds shall be $\frac{1}{2}$ in. (13 mm)
 - (2) The maximum continuous length of fillet welds shall be not over 4 in. (102 mm)
 - (3) Electrodes or filler metal shall be dry and shall provide a low-hydrogen weld deposit. Chromemoly filler metals shall have a maximum specified chromium content of not more than 2.50% and a maximum specified carbon content of not more than 0.05%.
 - (4) The thickness of the test plate used in making the welding procedure qualification of Section IX shall not be less than that of the material to be welded.
 - (d) for tubes or pressure retaining handhole and inspection plugs or fittings with a specified maximum chromium content of 6% that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of $\frac{3}{8}$ in. (10 mm) or less, and preheat to a minimum temperature of 300°F (149°C) is applied when the thickness of either part exceeds $\frac{5}{8}$ in. (16 mm)
- (2) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 6 Group No. 1,2,3	1,400 (760)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	5 hr plus 15 min for each additional inch over 5 in. (127 mm)

NOTES:

- (1) Postweld heat treatment is not mandatory for P-No. 6 materials under the following conditions:
- for Type 410 material where the material and construction shall comply with the following conditions:
 - a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.08%
 - the electrodes used shall produce an austenitic chromium-nickel weld deposit, or a non-air-hardening nickel-chromium-iron weld deposit, and provided the following additional requirements are met:
 - the material thickness at the welded joint does not exceed $\frac{3}{8}$ in. (10 mm)
 - or material thickness over $\frac{3}{8}$ in. (10 mm) through $1\frac{1}{2}$ in. (38 mm), the following additional conditions shall be required:
 - a preheat of 450°F (232°C) shall be maintained during welding
 - the welded joints shall be fully radiographically examined
 - Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

throat thickness, and for partial penetration and material repair welds, the nominal thickness is the depth of the weld groove or preparation. For combination groove and fillet welds, nominal thickness is the total combined thickness of the deposited weld, groove depth plus fillet weld throat.

The holding time at temperature as specified in Table PW-39 need not be continuous. It may be an accumulation of time of multiple postweld heat treatment cycles.

PW-39.4 The weldments shall be postweld heat treated by any of the following methods.

PW-39.4.1 Heating the complete assembly as a unit.

PW-39.4.2 Heating sections of assemblies.

01 PW-39.4.3 In cases where the vessel is postweld heat treated in sections, the heat treatment of the final joints may be performed by one of the following methods.

PW-39.4.3.1 By uniformly heating a circumferential band around the vessel, to the temperature and for the time specified in Table PW-39 for postweld heat treatment. **01**

PW-39.4.3.2 Alternatively, the post weld heat treatment of the final joints may be performed by heating in the furnace, provided the overlap of the heated sections of the vessel is at least 5 ft. When this procedure is used, the portion outside of the furnace shall be thermally shielded (using blankets, brick, etc.) so that the temperature gradient is not harmful. **01**

PW-39.4.3.2.1 Where the cross section of the vessel that projects from the furnace contains a nozzle, consideration shall be given to controlling the temperature in the nozzle, so that the temperature gradient is not harmful. **01**

PW-39.5 Nozzles or other welded attachments for which postweld heat treatment is required may be locally postweld heat treated by one of the following methods. **01**

PW-39.5.1 By heating a circumferential band around the entire vessel with the welded connection **01**

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 7 Group No. 1,2	1,350 (732)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	5 hr plus 15 min for each additional inch over 5 in. (127 mm)

NOTES:

- (1) Postweld heat treatment for P-No. 7 material shall be performed as described in PW-39.3, except that the cooling rate shall be a maximum of 100°F/hr (56°C/hr) in the range above 1,200°F (649°C) after which the cooling rate shall be sufficiently rapid to prevent embrittlement.
- (2) Postweld heat treatment is not mandatory for P-No. 7 materials under the following conditions:
 - (a) for Type 405 material where the material and construction shall comply with the following conditions:
 - (1) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification) of not more than 0.08%
 - (2) the electrodes used shall produce an austenitic chromium-nickel weld deposit, or a non-air-hardening nickel-chromium-iron weld deposit, and provided the following additional requirements are met:
 - (a) the material thickness at the welded joint does not exceed $\frac{3}{8}$ in. (10 mm)
 - (b) for material thickness over $\frac{3}{8}$ in. (10 mm) through $1\frac{1}{2}$ in. (38 mm), the following additional requirements are met:
 - (1) a preheat of 450°F (232°C) shall be maintained during welding
 - (2) the welded joints shall be fully radiographically examined

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 8	None	None	None	None

NOTE:

- (1) Postweld heat treatment is neither required nor prohibited for joints between austenitic stainless steels of the P-No. 8 group.

located at the middle of the band. Except as modified below, the soak band shall extend around the entire vessel, and shall include the nozzle of welded attachment.

- 01 PW-39.5.1.1** By heating a circumferential band around the entire vessel with the welded connection located at the middle of the band. Provided the required soak band around the nozzle or attachment weld, as defined in PW-39.3, is heated to the required temperature and held for the required time, as specified in Table PW-39, the remainder of the circumferentially-heated band may be varied in width around the circumference

of the vessel. The temperature within the heated band shall be controlled to prevent harmful gradients.

PW-39.5.1.2 By heating a circumferential band around the entire vessel with the welded connection located at the middle of the band. Provided the required soak band around the nozzle or attachment weld, as defined in PW-39.3, is heated to the required temperature and held for the required time, as specified in Table PW-39, the remainder of the circumferentially-heated band need not reach the required post weld heat treatment temperature. The temperature within the heated band shall be controlled to prevent harmful gradients.

01

TABLE PW-39 (CONT'D)
MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT
OF PRESSURE PARTS AND ATTACHMENTS

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 10I Group No. 1	1,250 (677)	1 hr/in. (1 hr/25 mm), 15 min minimum	1 hr/in. (1 hr/25 mm)	1 hr/in. (1 hr/25 mm)

NOTES:

- (1) Postweld heat treatment for P-No. 10I (SA-268 TP446 material only) shall be performed as described in PW-39.3, except that the cooling rate shall be a maximum of 100°F/hr (56°C/hr) above 1,200°F (649°C) after which the cooling rate shall be sufficiently rapid to prevent embrittlement.

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 31	None	None	None	None

NOTE:

- (1) Postweld heat treatment is neither required nor prohibited for joints between materials of the P-No. 31 group.

Material	Minimum Holding Temperature, °F (°C)	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in. (51 mm)	Over 2 in. (51 mm) to 5 in. (127 mm)	Over 5 in. (127 mm)
P-No. 45	None	None	None	None

NOTE:

- (1) Postweld heat treatment is neither required nor prohibited for joints between materials of the P-No. 45 group.

TABLE PW-39.1
ALTERNATE POSTWELD HEAT TREATMENT
REQUIREMENTS FOR CARBON AND
LOW ALLOY STEELS
 (Applicable only when permitted in Table PW-39)

Decrease in Temperature Below Minimum Specified Temperature, °F (°C)	Minimum Holding Time [Note (1)] at Decreased Temperature, hr/in. (hr/25 mm) of Thickness	Notes
50 (28)	2	...
100 (56)	4	...
150 (83)	10	(2)
200 (111)	20	(2)

NOTES:

- (1) Minimum holding time per inch for thickness up to and including 2 in. (51 mm). Add 15 min per inch of thickness for thickness greater than 2 in. (51 mm).
- (2) These lower postweld heat treatment temperatures permitted only for P-No. 1, Group 1 and 2 materials.

01 PW-39.5.2 Local areas around nozzles or welded attachments in the larger radius sections of double curvature heads, or spherical shells or heads, may be post weld heat treated by heating a circular region around the nozzle. This region, or soak band, shall include the nozzle or welded attachment and shall be measured from the center of the nozzle or attachment. The soak band shall be a circle whose radius is equal to the radius at the widest width of the width of the weld attaching the nozzle or attachment to the shell, plus the thickness of the shell or head, or 2 in., whichever is less. The portion of the vessel outside of the circular region shall be thermally shielded using blankets, brick, or other suitable insulation material so that the temperature gradient is not harmful. A greater amount of base material may also be heated to permit temperature gradient control.

01 PW-39.5.3 Nozzles that contain circumferential welds in close proximity to a vessel or shell have additional thermal restraint imposed by this close proximity. Adequate length between the weld on the nozzle and the shell shall be provided so that the post weld heat treatment does not introduce harmful stresses at the nozzle attachment weld. Alternatively, the weld may be post weld heat treated by heating a full circumferential band around the entire vessel or shell, which shall include the nozzle in the center of the band.

01 PW-39.6 In the case of local postweld heat treatment of welded joints in pipes, tubes, and headers, the soak band shall extend around the entire pipe tube or header.

PW-39.7 Electroslag welds in ferritic materials over $1\frac{1}{2}$ in (38 mm). in thickness at the joint shall be given a grain refining (austenitizing) heat treatment.

PW-40 REPAIR OF DEFECTS

01

PW-40.1 Weld imperfections, such as cracks, pinholes, and incomplete fusion, detected visually or by leakage tests or by the examinations described in PW-11 and found to be rejectable, shall be removed by mechanical means or by thermal grooving processes, after which the joint shall be rewelded and reexamined.

PW-40.2 When tube-to-header or tube-to-drum welded joints have already received the postweld heat treatment required by PWT-11 and PW-39, minor local additional welding for rework of the joint or to improve the fillet weld contour may be performed on the materials listed in (2) below without repeating the postweld heat treatment, subject to all the following limitations.

01

(1) The depth of any rework welding below the surface shall not exceed the smaller of 10% of the thickness of the drum or header, or 50% of the wall thickness of the tube.

(2) The area to be rework welded shall be preheated to at least the minimum temperatures as indicated below for the material:

Material Welding P-Number Group	Minimum Preheat, °F (°C), for Rework Welding
P-No.1	200 (93)
P-No.3, Groups 1 & 2	200 (93)
P-No.4	250 (121)
P-No.5A	300 (149)

(3) The tubes shall not exceed 4 in. (102 mm) O.D. except for P-No. 1 material, which shall not exceed $6\frac{5}{8}$ in. (168 mm) O.D.

(4) The welding procedure used for the rework welding shall have been qualified to the requirements of Section IX for the thickness of rework welding to be performed and for the omission of postweld heat treatment.

PW-40.3 Defects in P-No. 1 Group Nos. 1, 2, and 3 materials, and in P-No. 3 Group Nos. 1 and 2 materials, and in the welds joining these materials, may be weld repaired after the final PWHT but prior to the final hydrostatic test. The welded repairs shall meet the requirements below.

01

PW-40.3.1 Base materials. The defect shall be removed or reduced to an acceptable size. If the defect was required to be removed, the groove shall be exam-

01

ined to verify defect removal, using either the magnetic particle or the liquid penetrant examination methods. The acceptance standards for the examination shall be in accordance with the requirements of the original base material specification.

- 01 PW-40.3.2 Welds and Welded Repairs.** The defect shall be removed, and the groove examined to verify defect removal, using either the magnetic particle or the liquid penetrant examination methods. The acceptance standard for the examination shall be in accordance with the following paragraphs.

- 01 PW-40.3.2.1 Evaluation of Indications.** Indications will be revealed by retention of dye, or magnetic particles. All such indications are not necessarily imperfections, since excessive surface roughness or magnetic permeability variations may produce similar indications. Only indications that have any dimension greater than $\frac{1}{16}$ in. shall be considered relevant. Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

(a) A linear indication is one having a length greater than three times its width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

- 01 PW-40.3.2.2 Acceptance Standards.** All surfaces to be examined shall be free of:

(a) relevant linear indications;

(b) relevant rounded indications greater than $\frac{3}{16}$ in.; and

(c) four or more relevant rounded indications in a line separated by $\frac{1}{16}$ in. or less edge to edge. An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation.

- 01 PW-40.3.3** The total repair depth shall not exceed 10% of the base material thickness. The total depth of a weld repair shall be taken as the sum of the depths for repairs made from both sides of a weld at a given location. The total area of such repairs shall not exceed 100 sq in.

- 01 PW-40.3.4** In addition to the requirements of Section IX for qualification of welding procedure specifications for groove welds, the following requirements shall apply.

(a) The weld procedure qualification shall have been made using material of the same P-No. and Group No. as the material to be repaired. The specific welding technique or combination of welding techniques used shall have been developed and tested to assure adequate

tempering of the underlying weld bead heat affected zones.

(b) The weld metal shall be deposited by the manual shielded metal-arc process. Only low hydrogen welding electrodes shall be used. The electrodes shall be properly conditioned in accordance with Section II, Part C, SFA-5.5, Appendix A5.6.

(c) The maximum heat input for each weld layer shall not exceed that used in the procedure qualification test.

(d) The maximum deposited weld bead width for any electrode shall be four times the electrode core diameter.

(e) The repair area, including a band equal in width to 4 in. or four times the thickness of the weld repair, whichever is greater, on either side of the groove, shall be preheated and maintained at a minimum temperature of 350°F during welding. The maximum interpass temperature shall be 450°F.

(f) The repair weld method shall be limited to the half bead weld repair technique as follows. The initial layer of weld metal shall be deposited over the entire area using $\frac{1}{8}$ in. maximum diameter electrodes. Approximately one half the thickness of this layer shall then be removed by grinding before depositing subsequent layers. The subsequent weld layers shall be deposited using $\frac{5}{32}$ in. maximum diameter electrodes, in such a manner as to assure tempering of the prior weld beads and their heat affected zones. A final temper bead weld shall be applied to a level above the surface being repaired without contacting the base material, but close enough to the edge of the underlying weld bead, to assure tempering of the base material heat affected zone.

PW-40.3.5 For materials greater than 1 in. thick, **01** after completing all welding, the repair area shall be heated to and maintained at a temperature of 450°–550°F for a minimum period of 4 hr.

PW-40.3.6 Any final temper bead reinforcement **01** shall then be removed substantially flush with the surface of the base material.

PW-40.3.7 After the finished repair weld has **01** reached ambient temperature, it shall be examined to the requirements of PW-40.3.2, using the same nondestructive examination technique that was used to examine the weld groove.

PW-40.3.8 The vessel shall be hydrostatically **01** tested in accordance with PW-54.

PW-40.3.9 The Manufacturer shall obtain the ap- **01** proval of the Authorized Inspector, prior to making the repair.

PW-41 CIRCUMFERENTIAL JOINTS IN PIPES, TUBES, AND HEADERS

The rules in the following paragraphs apply specifically to the boiler proper and parts thereof.

PW-41.1 Circumferential welded butt joints in pipe, tubes, and headers shall meet the radiographic and ultrasonic examination requirements of Table PW-11.

PW-41.2 All circumferential arc or gas welded joints of parts covered by this paragraph and welded in accordance therewith shall have a double-welded butt joint or a single-welded butt joint made the equivalent of a double-welded butt joint, except as otherwise provided in PW-41.4 and PW-41.5.

PW-41.2.1 The strength of the weld shall be sufficient to develop the full strength of the part in the longitudinal direction. There shall be no valley or groove along the edge or in the center of the weld except as permitted by PW-35.1. Weld reinforcement may be removed if so desired. The design of the joint and the method of welding shall be such that there will be no appreciable projection of weld metal past the inside surface.

PW-41.2.2 In welding single-welded butt joints, complete penetration at the root is required. This shall be demonstrated by the qualification of the procedure to be used. If complete penetration cannot otherwise be secured, the procedure shall include a backing ring or equivalent. The depth of weld measured between the inside surface of the weld preparation and the outside surface of the pipe or tube shall be not less than the minimum thickness permitted by the applicable material specifications for the particular size and thickness of pipe or tubing used. Where backing rings are not used, concavity of the root surface is permitted if the depth of the concavity of the weld metal does not exceed the lesser of $\frac{3}{32}$ in. or 20% of the thinner of the two sections being joined. The contour of the concavity shall be smooth and the resulting thickness of the weld, including reinforcement, shall be at least equal to the required thickness of the thinner section. Concavity depth allowed under the rules of this paragraph shall be reduced by an amount equal to any net section replacement used, as permitted in PW-41.2.3.

PW-41.2.3 When the wall is recessed for a backing ring or to assure a uniform inside diameter of the weld preparation, the depth of such recess shall be so limited that the remaining net section of the wall is not less than the minimum required thickness. For boiler and superheater tubes where the diameter does not exceed 4 in. (152 mm), the recess may reduce the required

thickness by not more than $\frac{1}{32}$ in. (0.8 mm), provided the reduced net section is replaced by weld metal in the outside reinforcement such that the resulting thickness of the weld, including reinforcement, is at least equal to the minimum required thickness.

PW-41.2.4 Backing rings may be of any size or shape suitable for the welding process and may be left in place or removed as desired. Materials for backing rings shall be compatible with the weld metal and base material and shall not cause harmful alloying or contamination. If left in place they must be properly secured to prevent dislodgment and shall have a contour on the inside to minimize the restriction to flow, if needed, and be of such inside diameter as to permit the passage of a tube cleaner where such cleaner is to be used.

PW-41.2.5 When welded joints in tubes or pipes are not postweld heat treated, the procedure qualification test shall be made under the same conditions, but the performance qualification test may be made on either postweld heat treated or nonpostweld heat treated samples.

PW-41.3 Pipe connections not exceeding NPS $\frac{1}{2}$ (DN 15) may be welded to pipe or headers under the provisions of this paragraph without the inspection required by this Section.

PW-41.4 For attachment of nozzles to boiler drums or headers see PW-15.

PW-41.5 Welded socket type joints or sleeve type joints may be used to connect pipe or tubes to valves or fittings, or to each other, provided the following conditions are met.

PW-41.5.1 Pipe shall not exceed NPS 3 (DN 80) and tubing shall not exceed $3\frac{1}{2}$ in. (89 mm) nominal outside diameter (see PG-42, for ANSI socket welding components).

PW-41.5.2 The depth of insertion of a pipe or tube into a socket shall be at least $\frac{1}{4}$ in. (6 mm). There shall be at least $\frac{1}{16}$ in. (1.6 mm) clearance between the end of the pipe or tube and the internal shoulder of the socket, before welding.

PW-41.5.3 The fit between the socket or sleeve and the pipe or tube shall conform to applicable standards for socket weld fittings, and in no case shall the inside diameter of the socket or sleeve exceed the outside diameter of the pipe or tube by more than 0.080 in. (2.03 mm).

PW-41.5.4 The average outside diameter of the hub or sleeve (collar or end portion of socket welding fittings) shall be sufficient to make the average hub or sleeve thickness not less than 1.09 times the nominal thickness of the pipe or tube.

PW-41.5.5 The throat dimension of the fillet weld shall be not less than 0.77 times the nominal thickness of the pipe or tube.

PW-41.5.6 The welded joint shall not be in contact with furnace gases (see PW-41.1.4.2).

PW-41.5.7 The depth of the insertion of a pipe or tube into a sleeve shall be at least $\frac{1}{4}$ in. (6 mm). There shall be at least $\frac{1}{16}$ in. (1.6 mm) clearance between the butting ends of the pipe or tube, before welding.

PW-42 JOINTS IN VALVES AND OTHER BOILER APPURTENANCES

Valves, other boiler appurtenances such as water columns, and casings of pumps that are part of a boiler circulation system, may have fusion-welded joints other than longitudinal, complying with the requirements of this Part except that inspection of these joints is not required. The Manufacturer shall furnish, if requested, a statement certifying that these requirements have been met.

PW-43 LOADING ON STRUCTURAL ATTACHMENTS

PW-43.1 Loads imposed on steel tube walls by welded or mechanical attachments which produce bending stresses that are additive to bursting stresses shall conform to the following:

$$\text{PW-43.1.1} \quad L \leq L_a$$

where

L = actual unit load calculated from PW-43.1.2, lb/in. (kN/m)

L_a = maximum allowable unit load, lb/linear in. of attachment from PW-43.2, lb/in. (kN/m)

$$\text{PW-43.1.2} \quad L = W_r / \ll \pm 6We / \ll^2$$

where

W_r = load component normal to tube axis, lb (kN)

W = eccentric load applied to lug, lb (kN)

$\ll$ = length of attachment of tube, in. (mm)

e = eccentricity of W , in. (mm) (see Fig. PW-43.2)

In determining the allowable loading per inch (25 mm) of length of attachment on a tube bend, the

allowable unit load determined by using the outside diameter of the tube shall be increased by the amount of allowable compression unit load for a tube having an outside diameter equivalent to the outside diameter of the bend and having a wall thickness the same as that of the tube bend (see Fig. A-74). For an alternative method of determining the maximum allowable loading on structural attachments to tubes, see A-73.2 for conducting tests on full-size sections of tubes.

PW-43.2 Procedure for determining L_a in the equation in PW-43.1.1.

Step 1: Determine K from Table PW-43.1.

Step 2: Determine load factor L_f for compression or tension loading on lug from Fig. PW-43.1, or from PW-43.2.1 or PW-43.2.2, when the range of the curves in Fig. PW-43.1 does not extend far enough to cover specific cases.

PW-43.2.1 Compression Loading

$$L_f = 1.618X^{[-1.020 - 0.014 \log X + 0.005 (\log X)^2]}$$

PW-43.2.2 Tension Loading

$$L_f = 49.937X^{[-2.978 + 0.898 \log X - 0.139 (\log X)^2]}$$

Step 3: Determine S_t .

PW-43.2.3 Available Stress

$$S_t = 2.0 S_a - S$$

Step 4: Using values obtained in Steps 1 through 3, determine maximum allowable unit load, lb/in. (kN/m)

PW-43.2.4 Allowable Unit Load

$$L_a = K(L_f)S_t$$

where

K = tube attachment width design factor from Table PW-43.1, dimensionless

L_f = a compression or tension load factor, in. (mm)

S_t = portion of allowable stress available for attachment loading, from PW-43.2.3, psi (kPa)

D = outside diameter of tube, in. (mm)

t = tube wall thickness, in. (mm)

$X = D/t^2$, a parameter used to determine L_f 1/in. (1/mm)

S_a = allowable stress value from Table 1A of Section II, Part D

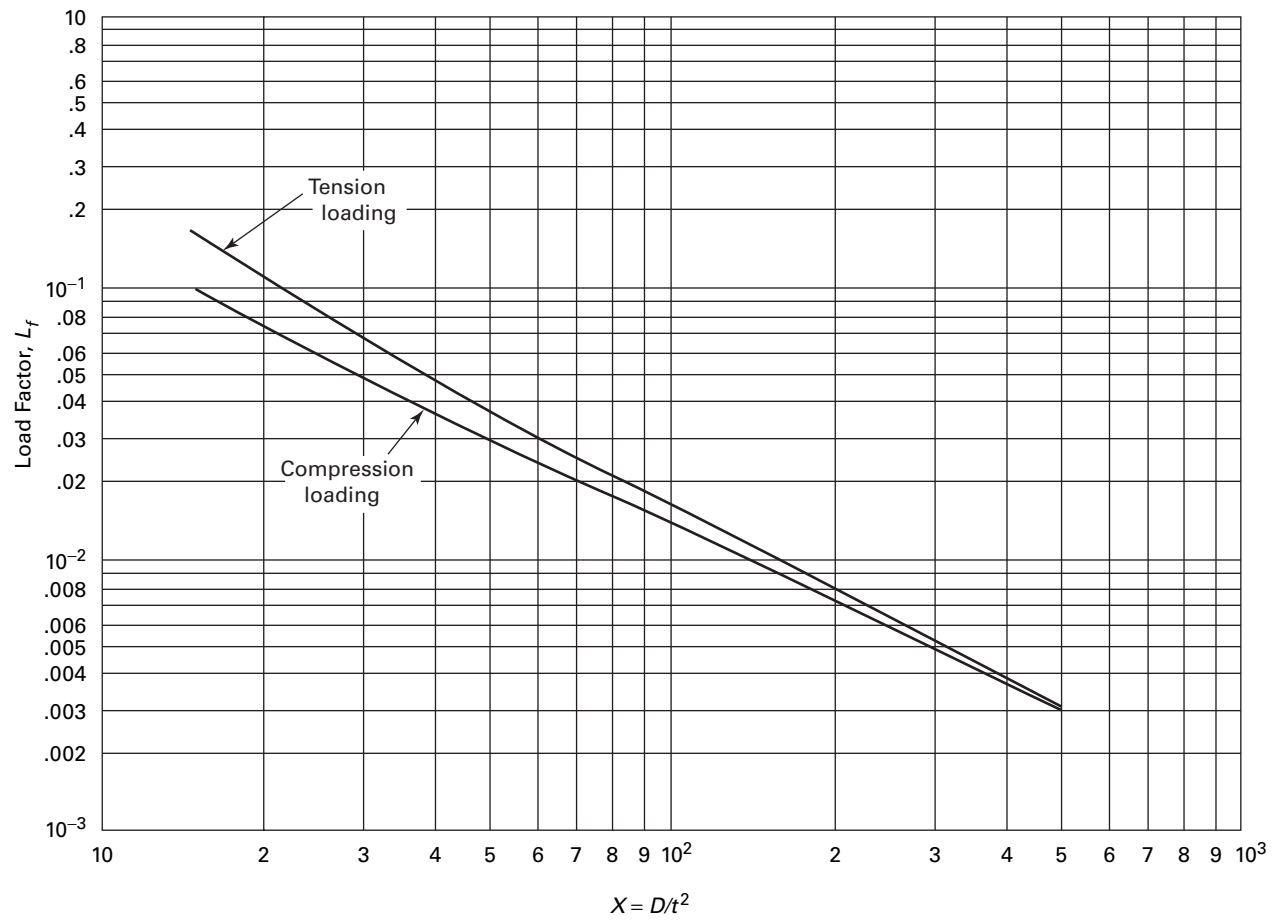
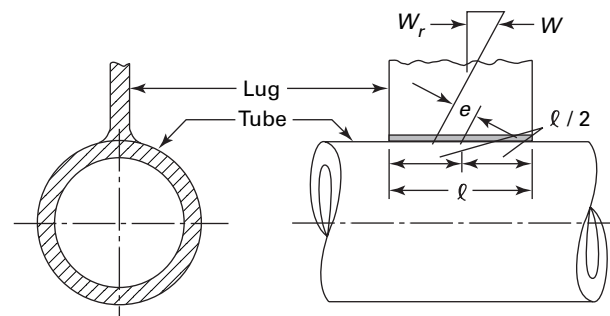
FIG. PW-43.1 CHART FOR DETERMINING LOAD FACTOR, L_f 

FIG. PW-43.2 METHOD OF COMPUTATION OF ATTACHMENTS TO TUBES

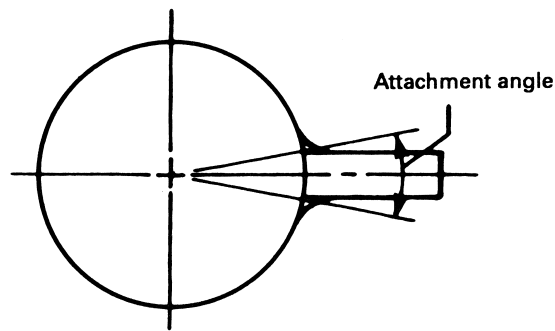


TABLE PW-43.1
TUBE ATTACHMENT ANGLE DESIGN FACTOR, K

Angle of attachment, deg	0	5	10	15	20	25	30	35	40	45
Design factor, K	1.000	1.049	1.108	1.162	1.224	1.290	1.364	1.451	1.545	1.615
Angle of attachment, deg	50	55	60	65	70	75	80	85	90	
Design factor, K	1.730	1.836	1.949	2.076	2.221	2.341	2.513	2.653	2.876	

S = pressure stress in tube determined by the equation in PG-27.2.1, psi (kPa)

$\log$ = logarithm to base 10

struction have been qualified under the provisions of Section IX. The Manufacturer shall submit evidence to the Inspector that those requirements have been met.

INSPECTION AND TESTS

PW-46 GENERAL

PW-46.1 The rules in the following paragraphs apply specifically to the inspection and testing of power boilers and power boiler parts that are fabricated by welding and shall be used in conjunction with the general requirements for inspection and tests in Part PG as well as the specific requirements for inspection and tests in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PW-46.2 Inspection During Fabrication. The Manufacturer shall submit the vessel or other pressure part for inspection at such stages of the work as may be designated by the Inspector.

PW-47 CHECK OF WELDING PROCEDURE

PW-47.1 It is the duty of the Inspector to assure himself that the welding procedures employed in con-

PW-47.2 The Inspector has the right at any time to call for and witness the test welding and testing although it is not mandatory that he witness the test welding and the testing unless he so desires.

PW-48 CHECK OF WELDER AND WELDING OPERATOR PERFORMANCE QUALIFICATIONS

PW-48.1 It is the duty of the Inspector to assure himself that all welding is done by welders or welding operators qualified under the provisions of Section IX. The Manufacturer shall make available to the Inspector a certified copy of the record of performance qualification tests of each welder and welding operator as evidence that these requirements have been met.

PW-48.2 The Inspector has the right at any time to call for and witness the test welding and testing although it is not mandatory that he witness the test welding and the testing unless he so desires.

PW-49 CHECK OF HEAT TREATMENT PRACTICE

The Inspector shall satisfy himself that all heat treating operations required by the Code have been correctly performed.

PW-51 ACCEPTANCE STANDARDS FOR RADIOGRAPHY

PW-51.1 All welds for which a complete radiographic examination is required by PW-11 shall be radiographically examined throughout their entire length by the X-ray or gamma-ray method in accordance with Article 2 of Section V, except that the requirements of T-285 are to be used as a guide but not for the rejection of radiographs unless the geometrical unsharpness exceeds 0.07 in. (1.8 mm).

PW-51.2 A single-welded circumferential butt joint with backing strip may be radiographed without removing the backing strip, provided it is not to be removed subsequently and provided the image of the backing strip does not interfere with the interpretation of the resultant radiographs.

PW-51.3 Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions, and shall be repaired as provided in PW-40 and the repair radiographed to PW-51:

PW-51.3.1 Any indication characterized as a crack, or zone of incomplete fusion or penetration.

PW-51.3.2 Any other elongated indication on the radiograph that has a length greater than:

- (a) $\frac{1}{4}$ in. (6 mm) for t up to $\frac{3}{4}$ in. (19 mm);
 - (b) $\frac{1}{3} t$ for t from $\frac{3}{4}$ in. (19 mm) to $2\frac{1}{4}$ in. (57 mm);
 - (c) $\frac{3}{4}$ in. (19 mm) for t over $2\frac{1}{4}$ in. (57 mm)
- where t is the thickness of the weld.

PW-51.3.3 Any group of aligned indications that have an aggregate length greater than t in a length of $12t$, except when the distance between the successive imperfections exceeds $6L$ where L is the length of the longest imperfection in the group.

PW-51.3.4 Rounded indications in excess of those shown in Appendix A-250.

PW-51.4 A complete set of radiographs for each job shall be retained by the Manufacturer and kept on file for a period of at least 5 years.

PW-51.5 The Manufacturer shall certify that personnel performing and evaluating radiographic examinations required by Section I have been qualified and certified in accordance with their employer's written practice. SNT-TC-1A³ or CP-189 shall be used as a guideline for employers to establish their written practice for qualifications and certification of their personnel. Alternatively, the ASNT Central Certification Program (ACCP) may be used to fulfill the examination and demonstration requirements of SNT-TC-1A and the employer's written practice. Provisions for training, experience, qualification, and certification of NDE personnel shall be described in the Manufacturer's quality control system (see PG-105.4).

When personnel have been certified according to their employer's written practice based upon an edition of SNT-TC-1A, ACCP, or CP-189 earlier than that referenced in A-360, their certification shall be valid for performing nondestructive examination required by this Section until their next scheduled recertification. Any recertifications, reexaminations, or new examinations shall be performed to the employer's written practice based on the edition of SNT-TC-1A, ACCP, or CP-189 referenced in A-360.

PW-52 ACCEPTANCE STANDARDS FOR ULTRASONIC EXAMINATION

PW-52.1 Technique and standards for ultrasonic examination shall follow Section V, Article 5.

PW-52.2 The Manufacturer's report, as required by T-590 of Section V, shall be retained by the Manufacturer for a minimum of 5 years.

PW-52.3 Acceptance-Rejection Standards. Imperfections that cause an indication greater than 20% of the reference level shall be investigated to the extent that the ultrasonic examination personnel can determine their shape, identity, and location, and evaluate them in terms of PW-52.3.1 and PW-52.3.2.

PW-52.3.1 Cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

PW-52.3.2 Other imperfections are unacceptable if the indication exceeds the reference level and their length exceeds the following:

- (a) $\frac{1}{4}$ in. (6 mm) for t up to $\frac{3}{4}$ in. (19 mm);

³ SNT-TC-1A, ACCP, and CP-189 are published by the American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, OH 43228-0518.

(b) $\frac{1}{3} t$ for t from $\frac{3}{4}$ in. (19 mm) to $2\frac{1}{4}$ in. (57 mm);

(c) $\frac{3}{4}$ in. (19 mm) for t over $2\frac{1}{4}$ in. (57 mm)

where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses.

- 01 **PW-52.4** The Manufacturer shall certify that personnel performing and evaluating ultrasonic examinations required by Section I have been qualified and certified in accordance with their employer's written practice. SNT-TC-1A³ or CP-189 shall be used as a guideline for employers to establish their written practice for qualification and certification of their personnel. Alternatively, the ASNT Central Certification Program (ACCP) may be used to fulfill the examination and demonstration requirements of SNT-TC-1A and the employer's written practice. Provisions for training, experience, qualification, and certification of NDE personnel shall be described in the Manufacturer's quality control system (see PG-105.4).

When personnel have been certified according to their employer's written practice based upon an edition of SNT-TC-1A, ACCP, or CP-189 earlier than that referenced in A-360, their certification shall be valid for performing nondestructive examination required by this Section until their next scheduled recertification. Any recertifications, reexaminations, or new examinations shall be performed to the employer's written practice based on the edition of SNT-TC-1A, ACCP, or CP-189 referenced in A-360.

PW-53 TEST PLATES

PW-53.1 Vessel Test Plates. Cylindrical pressure parts subject to internal pressure, except such cylindrical pressure parts constructed of P-No. 1 materials as defined in Section IX, that are fabricated by fusion welding, such as drums and shells but not pipe, tubes, and headers shall meet the test requirements in PW-53.2 through PW-53.10.

PW-53.2 Welded Test Plates. A welded test plate having the dimensions shown in Fig. PW-53.1 shall be prepared from plate of the same material specification,⁴ the same or greater thickness as the weld at the joint and using the same welding procedure as used for the shell plates

⁴To be of the same specification as the steel being welded the chemical composition must be within the specification limits and the melting practice, i.e. killed, semikilled, or rimmed, must be the same.

that it represents. The plate shall be welded by one of the following methods. Either method may represent both longitudinal and circumferential joints.

PW-53.2.1 Attach the test plate as shown in Fig. PW-53.2 to one end of one longitudinal joint of each vessel so that the edges to be welded are a continuation of the corresponding edges of the longitudinal joint. In this case the weld metal shall be deposited in the weld joint of the test plate continuously with that deposited in the shell joint. This procedure is not applicable to vessels with circumferential joints only.

PW-53.2.2 Weld the joint in the test plate without attaching it as a continuation of a joint in the shell plate.

PW-53.3 When noncylindrical pressure parts are not integral with the vessel, a test plate shall be provided having a thickness not less than that of the parts.

PW-53.4 Where there are several pressure parts of any one design being welded in succession, the plates of which are of the same material that is covered by the welding procedure, a test plate shall be furnished for each 200 ft (61 m), or fraction thereof, of the main welded joints. The thickness of the thinnest plate and of the thickest plate shall not differ by more than $\frac{1}{4}$ in. (6 mm).

PW-53.5 Where more than one welder or welding operator is used on a vessel, the inspector may designate the welder or welding operator who shall make the required test plate.

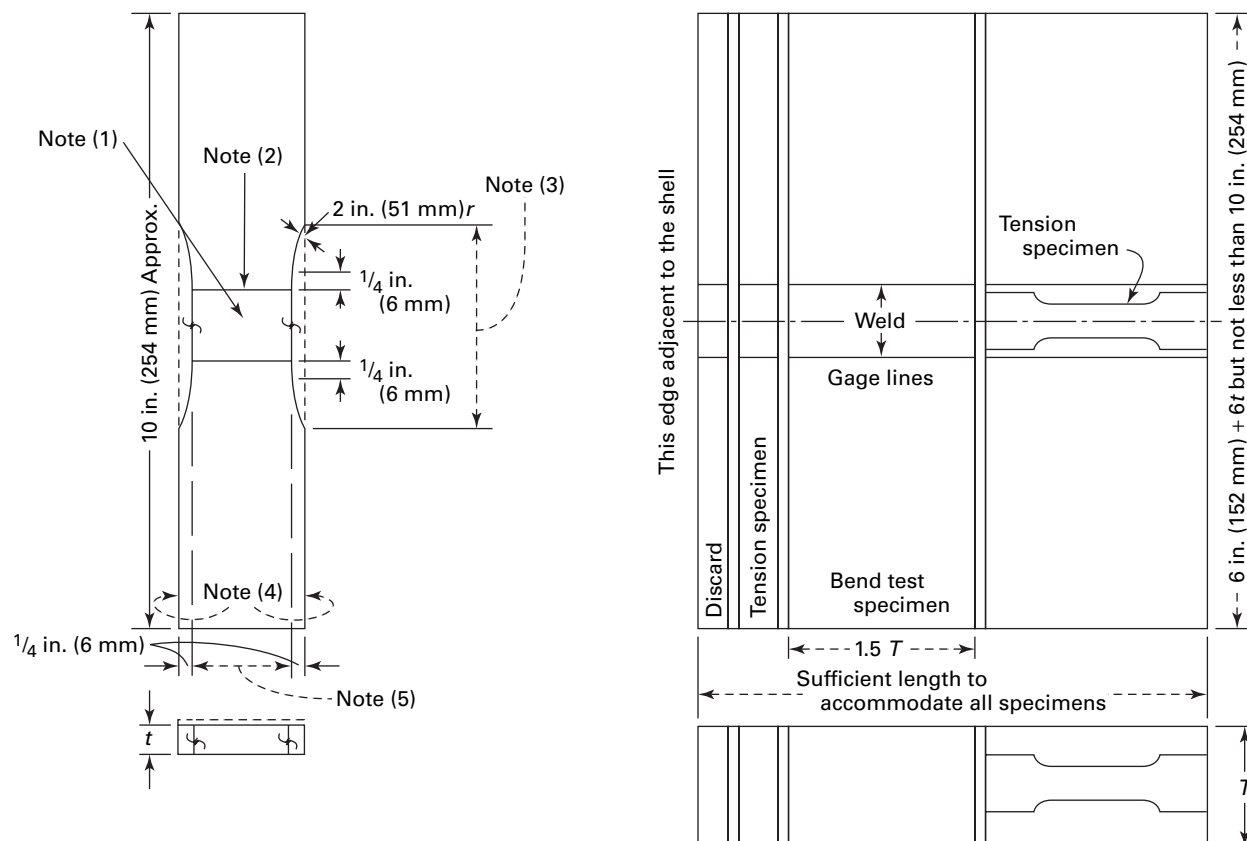
PW-53.6 The test plate shall be so supported that the welding does not warp the plate out of line by an angle greater than 5 deg. The plate shall be straightened before postweld heat treatment to remove any warping that has occurred. The test plate shall be given the same preheat treatment and the same postweld heat treatment as the vessel that it represents. In no case shall the temperature of preheat or postweld heat treatment be higher than that used for the vessel.

PW-53.7 Test Specimens. The coupons for tension and bend test shall be removed as shown in Fig. PW-53.1 and be of the dimensions shown in Fig. PW-53.1 and Fig. PW-53.3.

PW-53.8 Tension Tests

PW-53.8.1 Except as provided in PW-53.8.5 two types of tension test specimen are required, one of the joint and the other of the weld metal.

PW-53.8.2 The tension specimen of the joint shall be transverse to the welded joint and shall be the full thickness of the welded plate after the outer and inner surfaces



NOTES:

- (1) Weld reinforcement shall be machined flush with base metal.
- (2) Edge of widest face of weld.
- (3) This section machined preferably by milling.
- (4) These edges may be flame cut.
- (5) $W = 1\frac{1}{2}$ in. (38 mm) ± 0.01 in. (0.2 mm), if t does not exceed 1 in. (25 mm);
 $W = 1$ in. (25 mm) ± 0.01 in. (0.2 mm), if t exceeds 1 in.

FIG. PW-53.1 TEST SPECIMENS FROM LONGITUDINAL WELDED TEST PLATES

of the weld have been machined to a plane surface flush with the surface of the plate. When the capacity of the available testing machine does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall be tested and shall meet the requirements.

PW-53.8.3 If the tension test specimen shown in Fig. PW-53.1 breaks in the weld, its tensile strength shall be not less than the minimum of the specified tensile range of the base material. (The tension test of the joint specimen as specified herein is intended as

test of the welded joint and not of the plate.) When the specimen breaks outside the weld at not less than 95% of the minimum of the specified tensile range of the base material and the weld shows no sign of weakness, the test shall be accepted as meeting the requirements. When the specimen or a portion thereof breaks in the base material below this strength tolerance because of a local defect, one additional specimen shall be tested and shall meet the requirements.

PW-53.8.4 The tension test specimen of the weld metal shall be taken entirely from the deposited weld metal and shall meet the following requirements:

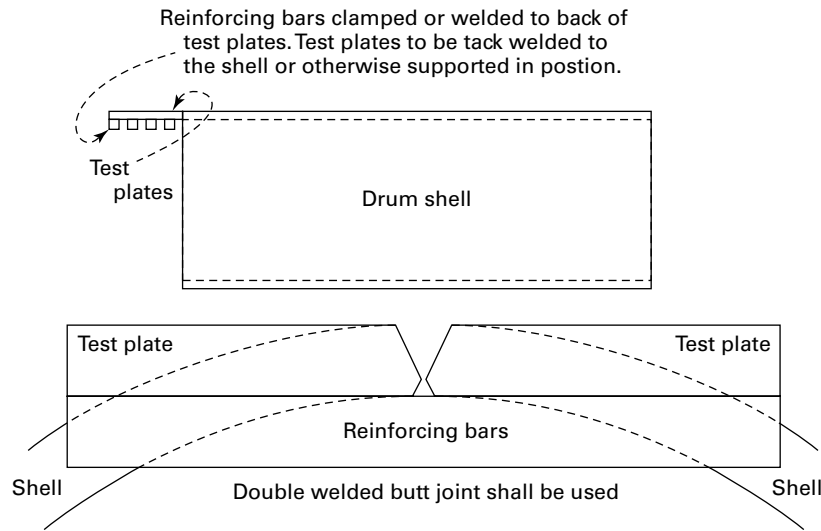


FIG. PW-53.2 METHOD OF FORMING LONGITUDINAL TEST PLATES

Tensile strength = at least that of the minimum of the range of the plate which is welded

Elongation, minimum, %, in 2 in. (51 mm) = 20,

or $= 700,000/U$ ($4\,820\,000/U$ metric) + 10, whichever is less

where

U = minimum specified tensile strength of the material to be welded, psi, as given in the applicable stress table

PW-53.8.5 For plate thicknesses less than $\frac{5}{8}$ in. (16 mm), the all-weld metal tension test may be omitted.

PW-53.9 Bend Tests

PW-53.9.1 The bend test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross section with a width $1\frac{1}{2}$ times the thickness of the specimen. When the capacity of the available testing machines does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall be tested and shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the surface of the specimen. The edges of this surface shall be rounded to a radius not over 10% of the thickness of the test specimen. The specimen shall be bent cold under free bending conditions until the least elongation measured within or across approximately

the entire weld on the outside fibers of the bend test specimen is 30%, or $700,000/U$ ($4\,820\,000/U$) + 20%, whichever is less.

PW-53.9.2 When a crack is observed in the convex surface of the specimen between the edges before the elongation required in PW-53.8.1 is attained, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimen shall not be considered as a failure. The appearance of small imperfections in the convex surface shall not be considered as a failure if the greatest dimension does not exceed $\frac{1}{16}$ in. (1.6 mm).

PW-53.10 Retests

PW-53.10.1 Should any of the specimens fail to meet the requirements by more than 10%, no retest shall be allowed except that in the case of failure of the free-bend test specimen due to permissible imperfections, free-bend specimen retests may be allowed at the discretion of the Inspector.

PW-53.10.2 Should any of the specimens fail to meet the requirements by 10% or less, retests shall be allowed. A second test plate shall be welded by the same operator who welded the plate which did not meet the test requirements. The retest shall be made on specimens cut from the second plate.

PW-53.10.3 The retests shall comply with the requirements. For either of the tension retests, two specimens shall be cut from the second test plate, and both of these shall meet the requirements.

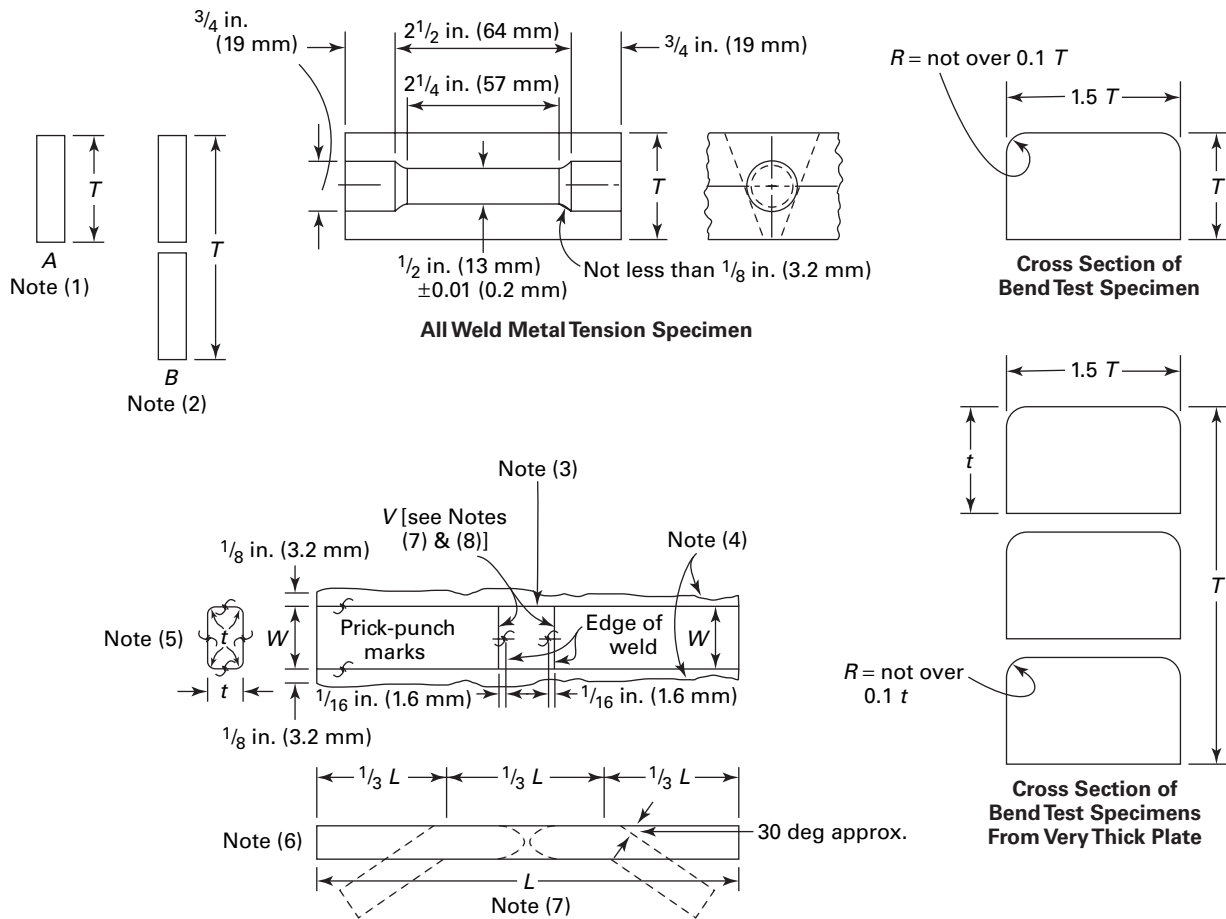


FIG. PW-53.3 DETAILS OF TEST SPECIMENS

PW-53.10.4 When there is more than one specimen of the same type and one or more of the specimens fail to meet the requirements by 10% or less, a retest may be made for each specimen required for the weld under consideration. Each such specimen shall meet the requirements.

PW-53.10.5 If the percentage of elongation of all-weld metal tension specimen is less than that specified and any part of the fracture is more than $\frac{3}{4}$ in. (19 mm) from the center of the 2 in. (51 mm) gage length of the specimen, a retest shall be allowed.

PW-54 HYDROSTATIC TEST

PW-54.1 Except as modified in PG-99.3, PG-106.8, and PW-54.3, all welded drums and other welded pressure parts shall be subjected to a hydrostatic test pressure of not less than 1.5 times the maximum allowable working pressure. The hydrostatic test may be made either in the Manufacturer's shop or in the field.

PW-54.2 When repairs are made, the part shall again be tested in the regular way, and if it passes the test the Inspector shall accept it. If it does not pass the test the Inspector may permit supplementary repairs, or if in his judgment the pressure part is not suitable for service, he may permanently reject it.

PW-54.3 Nonpressure parts may be welded to pressure parts after the hydrostatic test provided the following criteria are met:

(a) the welding is done in conformance with this Part (see PW-28);

(b) the welding is limited to P-No. 1 materials;

(c) the attachment is done by stud welding or with fillet welds where the throat of the weld is not to exceed the lesser of 0.70 times the thickness of the pressure part or $\frac{1}{4}$ in. (6 mm), and preheat to a minimum temperature of 200°F (93°C) is applied when the thickness of the pressure part exceeds $\frac{3}{4}$ in. (19 mm);

(d) the completed weld is inspected by the Authorized Inspector;

(e) the Manufacturers' Data Report Form shall be signed only after completion of the welding.

PART PR

REQUIREMENTS FOR BOILERS

FABRICATED BY RIVETING

Manufacturers using riveted construction shall use the 1971 Edition of Section I. Boilers or parts thereof constructed by using riveted construction require the use of the applicable Manufacturers' Data Report Forms as included in the 1971 Edition of Section I.

PART PB

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PART PB

REQUIREMENTS FOR BOILERS

FABRICATED BY BRAZING

GENERAL

PB-1 GENERAL

PB-1.1 Scope. The rules in Part PB are applicable to pressure parts of boilers, including piping constructed under the provisions of this Section, that are fabricated by brazing. These rules shall be used in conjunction with the general requirements in Part PG and the specific requirements in the applicable Parts of this Section that pertain to the type of boiler under consideration. The rules in Part PB are not applicable to non-pressure bearing attachments to pressure parts that have essentially no load-carrying function (such as extended heat transfer surface, insulation support pins, etc.).

PB-1.1.1 Definition of Brazing. A group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having liquidus above 840°F (450°C) and below the solidus of the base metal. The filler metal is distributed between the closely fitted faying surfaces of the joint by capillary action.

PB-1.1.2 Brazing processes that are permitted for use under this Part are classified by method of heating as follows:

- (a) torch brazing;
- (b) furnace brazing;
- (c) induction brazing;
- (d) resistance brazing;
- (e) dip brazing — salt and flux bath.

PB-1.2 Elevated Temperature. Maximum design temperature is dependent on the brazing filler metal and on the base metals being joined. The maximum design temperatures for some brazing filler metals are shown in Table PB-1.

PB-1.3 Service Restrictions. Brazed components may be used for service up to the temperatures as shown in Table PB-1 provided acceptable qualification tests are performed.

PB-1.4 Responsibility. Each Manufacturer¹ (Certificate of Authorization Holder) is responsible for the brazing done by his organization and shall establish the procedures and conduct the tests required by Section IX, and when necessary those required by this Section to qualify the brazing procedures used in the construction of brazed assemblies and the performance tests of brazers² who apply these procedures. Such brazing will ordinarily be done by employees of the Manufacturer who accepts the responsibility for Code construction of the boiler or part being brazed. Alternatively, the Manufacturer may perform Code brazing using the services of individual brazers who are not in his employ provided all the following conditions are met.

PB-1.4.1 All Code construction shall be the responsibility of the Manufacturer.

PB-1.4.2 All brazing shall be performed in accordance with Manufacturer's brazing procedure specifications that have been qualified by the Manufacturer in accordance with the requirements of Section IX and when necessary, based on design temperature, with the additional requirements of this Section.

PB-1.4.3 All brazers shall be qualified by the Manufacturer in accordance with the requirements of Section IX.

PB-1.4.4 The Manufacturer's quality control system shall include the following as a minimum.

PB-1.4.4.1 A requirement for complete and exclusive administrative and technical supervision of all brazers by the Manufacturer.

PB-1.4.4.2 Evidence of the Manufacturer's authority to assign and remove brazers at his discretion without involvement of any other organization.

¹ Manufacturer includes contractor, Assembler, and installer.

² Brazers includes brazing operator.

TABLE PB-1¹
MAXIMUM DESIGN TEMPERATURES [°F (°C)] FOR BRAZING FILLER METAL

Filler Metal Classification	Temperature Below Which Section IX Tests Only Are Required, °F (°C)	Temperature Range Requiring Section IX and Additional Tests, °F (°C)
BCuP	300 (149)	300–350 (149–177)
BAG	400 (204)	400–500 (204–260)
BCuZn	400 (204)	400–500 (204–260)
BCu	400 (204)	400–650 (204–343)
BAlSi	300 (149)	300–350 (149–177)
BNi	1,200 (649)	1,200–1,500 (649–816)
BAu	800 (427)	800–900 (427–482)
BMg	250 (121)	250–275 (121–135)

NOTE:

(1) Temperatures based on AWS recommendations.

PB-1.4.4.3 A requirement for assignment of brazer identification symbols.

PB-1.4.4.4 Evidence that this program has been accepted by the Manufacturer's Authorized Inspection Agency.

PB-1.4.5 The Manufacturer shall be responsible for Code compliance of the brazement including Code symbol stamping and providing Data Report Forms properly executed and countersigned by the Authorized Inspector.

Satisfactory qualification of the brazing procedure under Section IX and when necessary based on design temperature, with the additional requirements of this Section, is considered proof of the suitability of the filler metal. Brazing with brazing filler metals other than those listed in Section II, Part C, SFA-5.8 shall be separately qualified for both procedure and performance qualification in accordance with Section IX and when necessary with the additional requirements of this Section.

MATERIALS

PB-5 GENERAL

PB-5.1 Materials used in brazed construction of pressure parts shall conform to one of the specifications given in Section II and shall be limited to those specifically permitted in Parts PG, PWT, and PFT for which allowable stress values are given in Tables 1A and 1B of Section II, Part D for Section I Construction, and for which brazing group P-numbers are assigned in Section IX.

PB-5.2 Combinations of Dissimilar Metals. Combinations of dissimilar metals may be joined by brazing provided they meet the qualification requirements of Section IX and this Section.

PB-6 BRAZING FILLER METALS

The selection of the brazing filler metal for a specific application shall depend upon its suitability for the base metals being joined and the intended service.

PB-7 FLUXES AND ATMOSPHERES

Suitable fluxes or atmospheres or combinations of fluxes and atmospheres shall be used to prevent oxidation of the brazing filler metal and the surfaces to be joined. Satisfactory qualification of the brazing procedure under Section IX and when necessary, based on design temperature, with the additional requirements of this Section, is considered proof of the suitability of the flux and/or atmosphere.

DESIGN

PB-8 GENERAL

The rules in the following paragraphs apply to boilers and parts thereof that are fabricated by brazing and shall be used in conjunction with the general requirements for design in Part PG, as well as with the specific requirements for design in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PB-9 STRENGTH OF BRAZED JOINTS

It is the responsibility of the Manufacturer to determine from suitable tests or from experience that the specific brazing filler metal selected can produce a joint which will have adequate strength at design temperature. The strength of the brazed joint shall not be less than the strength of the base metal, or the weaker of the two base metals in the case of dissimilar metal joints.

PB-9.1 Qualification of Brazed Joints for Design Temperatures Up to the Maximum Shown in Column 1 of Table PB-1. Satisfactory qualification of the brazing procedure in accordance with part QB of Section IX is considered evidence of the adequacy of the base materials, the brazing filler metal, the flux and/or atmosphere, and other variables of the procedure.

PB-9.2 Qualification of Brazed Joints for Design Temperatures in the Range Shown in Column 2 of Table PB-1. For design temperatures in the range shown in Column 2 of Table PB-1, tests in addition to those in PB-9.1 are required. These tests shall be considered a part of the qualification procedure. For such design temperatures, two tension tests on production type joints are required, one at the design temperature and one at $1.05T$ (where T is the design temperature in degrees Fahrenheit). Neither of these production-type joints shall fail in the braze metal.

PB-10 BRAZED JOINT EFFICIENCY

The joint efficiency factor to be used in design of boilers with brazed joints shall be 1 for all joints.

PB-14 APPLICATION OF BRAZING FILLER METAL

The design of the joint shall provide for the application of the brazing filler metal. Where practicable, the brazing filler metal shall be applied in such a manner that it will flow into the joint or be distributed across the joint and produce visible evidence that it has penetrated the joint.

PB-14.1 Manual Application. The manual application of the brazing filler metal by face-feeding to a joint should be from one side only. Visual observation of the other side of the joint will then show if the required penetration of the joint by the filler metal has been obtained.

PB-14.2 Preplaced Brazing Filler Metal. The brazing filler metal may be preplaced in the form of slugs,

powder, rings, strip, cladding, spraying, or other means. After brazing, the brazing filler metal should be visible on both sides of the joint.

PB-15 PERMISSIBLE TYPES OF JOINTS

Some permissible types of brazed joints are shown in Fig. PB-15. Lap joints shall have a sufficient overlap to provide a higher strength in the brazed joint than in the base metal.

The nominal thickness of base material used with lap joints tested using the test fixture shown in Section IX, QB-462.1(e) shall not exceed $\frac{1}{2}$ in. (13 mm). There is no thickness limitation when specimens are tested without the test fixture shown in QB-462.1(e).

PB-16 JOINT CLEARANCE

The joint clearance shall be kept sufficiently small so that the filler metal will be distributed by capillary action. Since the strength of a brazed joint tends to decrease as the joint clearance is increased, the clearance for the assembly of joints in pressure vessels or parts thereof shall be within the tolerances set up by the joint design and used for the corresponding qualification specimens made in accordance with Section IX.

NOTE: For guidance, see Table PB-16, which gives recommended joint clearances at brazing temperature for varying types of brazing filler metal. Brazing alloys will exhibit maximum strength if clearances are maintained within these limits.

PB-17 JOINT BRAZING PROCEDURE

A joint brazing procedure shall be developed for each different type of joint of a brazed assembly. A recommended form for recording the brazing procedure is shown in QB-482 of Section IX. If more than one joint occurs in a brazed assembly, the brazing sequence shall be specified on the drawing or in instructions accompanying the drawing. If welding and brazing are to be done on the same assembly, the welding shall precede the brazing unless it is determined that the heat of welding will not adversely affect the braze previously made.

PB-18 OPENINGS

PB-18.1 Openings for nozzles and other connections shall be far enough away from any main brazed joint so that the joint and the opening reinforcement plates do not interfere with one another.

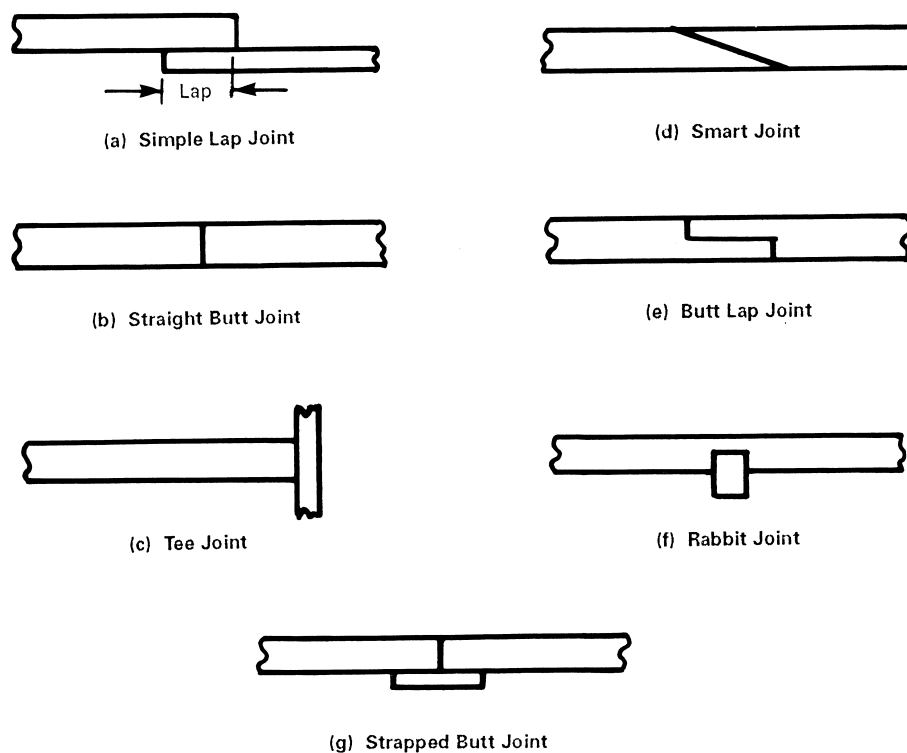


FIG. PB-15 SOME ACCEPTABLE TYPES OF BRAZED JOINTS

TABLE PB-16
RECOMMENDED JOINT CLEARANCE AT
BRAZING TEMPERATURE

Brazing Filler Metal	Clearance [Note (1)]	
	in.	mm
BAISi	0.006–0.010 for laps less than or equal to $\frac{1}{4}$ in.	0.15–0.25 for laps less than or equal to 6.35 mm
	0.010–0.025 for laps greater than $\frac{1}{4}$ in.	0.25–0.64 for laps greater than 6.35 mm
BCuP	0.001–0.005	0.02–0.13
BAg	0.002–0.005	0.05–0.13
BCuZn	0.002–0.005	0.05–0.13
BCu	0.000–0.002 [Note (2)]	0.000–0.05 [Note (2)]
BNi	0.001–0.005	0.02–0.13

NOTES:

(1) In the case of round or tubular members clearance on the radius is intended.

(2) For maximum strength use the smallest possible clearance.

PB-18.2 Openings for pipe connections in boilers having brazed joints may be made by inserting pipe couplings, or similar devices not exceeding NPS 3 (DN 80) in the shell or heads and securing them by welding provided the welding is performed by welders who have been qualified under the provisions of Section IX for the welding position and type of joint used. Such attachments shall conform to the rules for welded connections PW-15 and PW-16.

PB-19 BRAZED CONNECTIONS

PB-19.1 Connections such as saddle type fittings and fittings inserted into openings formed by outward flanging of the vessel wall, in sizes not exceeding NPS 3 (DN 80), may be attached to boilers by lap joints of brazed construction. Sufficient brazing shall be provided on either side of the line through the center of the opening parallel to the longitudinal axis of the shell to develop the strength of the reinforcement through shear in the brazing.

PB-19.2 For nozzle fittings having a bolting flange and an integral flange for brazing, the thickness of the flange attached to the boiler shall not be less than the thickness of the neck of the fitting.

FABRICATION

PB-26 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of boilers and parts thereof that are fabricated by brazing and shall be used in conjunction with the general requirements for fabrication in Part PG, as well as the specific requirements for fabrication in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PB-28 QUALIFICATION OF BRAZING PROCEDURE

PB-28.1 Each brazing procedure shall be recorded in detail by the Manufacturer. Each brazing procedure shall be qualified in accordance with Section IX and when necessary determined by design temperature with the additional requirements of this Section.

PB-28.2 Brazing of all test coupons shall be conducted by the Manufacturer. Testing of all test coupons shall be the responsibility of the Manufacturer. Qualification of a brazing procedure by one Manufacturer

shall not qualify that procedure for any other Manufacturer, except as provided in QB-201 of Section IX.

PB-29 QUALIFICATION OF BRAZERS AND BRAZING OPERATORS

PB-29.1 The brazers and brazing operators used in brazing pressure parts shall be qualified in accordance with Section IX.

The qualification test for brazing operators of machine or furnace brazing equipment shall be performed on a separate test plate prior to the start of brazing or on the first work piece.

PB-29.2 Each brazer or brazing operator shall be assigned an identifying number, letter, or symbol by the Manufacturer that shall be used to identify the work of that brazer or brazing operator.

PB-29.3 The Manufacturer shall maintain a record of the brazers and brazing operators showing the date and result of tests and the identification mark assigned to each. These records shall be certified by the Manufacturer and be accessible to the Inspector.

PB-29.4 Brazing of all test coupons shall be conducted by the Manufacturer. Testing of all test coupons shall be the responsibility of the Manufacturer. A performance qualification test conducted by one Manufacturer shall not qualify a brazer or brazing operator to do work for any other Manufacturer.

PB-30 CLEANING OF SURFACES TO BE BRAZED

The surfaces to be brazed shall be clean and free from grease, paint, oxides, scale, and foreign matter of any kind. Any chemical or mechanical cleaning method may be used that will provide a surface suitable for brazing.

PB-31 CLEARANCE BETWEEN SURFACES TO BE BRAZED

The clearances between surfaces to be brazed shall be maintained within the tolerances provided for by the joint design and used in the qualifying procedure. If greater tolerances are to be used in production, the joint must be requalified for those greater tolerances. The control of tolerances required may be obtained by using spot welding, crimping, or other means that will not interfere with the quality of the braze. If such means are employed in production, they must also be

employed in qualification of procedure, brazer, and operator.

PB-32 POSTBRAZING OPERATIONS

Brazed joints shall be thoroughly cleaned of flux residue by any suitable means after brazing and prior to inspection.³ Other postbrazing operations such as thermal treatments shall be performed in accordance with the qualified procedure.

PB-33 REPAIR OF DEFECTIVE BRAZING

Brazed joints that have been found to be defective may be rebrazed, where feasible, after thorough cleaning, by employing the same brazing procedure used for the original braze. If a different brazing procedure is employed, i.e., torch repair of furnace brazed parts, a repair brazing procedure shall be established and qualified.

When a repair brazing procedure is established it shall meet Section IX and other conditions set forth in this Section.

INSPECTION AND TESTS

PB-46 GENERAL

PB-46.1 The rules in the following paragraphs apply specifically to the inspection and testing of power boiler parts that are fabricated by brazing and shall be used in conjunction with the general requirements for inspection and tests in Part PG as well as the specific requirements for inspection and tests in the applicable Parts of this Section that pertain to the type of boiler under consideration.

PB-46.2 Inspection During Fabrication. The Manufacturer shall submit the boiler or other pressure part for inspection at such stages of the work as may be designated by the Inspector.

PB-47 CHECK OF BRAZING PROCEDURE

PB-47.1 The Inspector shall assure himself that the brazing procedure for each type of joint being produced is qualified in accordance with the requirements of Section IX and when necessary the additional require-

ments of this Section. He shall satisfy himself that each joint has been fabricated in accordance with the procedure. Where there is evidence of consistent poor quality, the Inspector shall have the right at any time to call for and witness tests of the brazing procedure.

PB-48 BRAZER AND BRAZING OPERATOR

PB-48.1 The Manufacturer shall certify that the brazing on a boiler or part thereof has been done by brazers or brazing operators who are qualified under the requirements of Section IX. The Inspector shall assure himself that only qualified brazers or brazing operators have been used.

PB-48.2 The Manufacturer shall make available to the Inspector a certified copy of the record of the qualification tests of each brazer and brazing operator. The Inspector shall have the right at any time to call for and witness tests of the ability of a brazer or brazing operator.

PB-49 VISUAL EXAMINATION

PB-49.1 When possible, the Inspector shall visually inspect both sides of each brazed joint after flux residue removal. It is recognized that for certain joints (blind joints) this is not possible.

PB-49.2 When visually possible there shall be evidence that the brazing filler metal has penetrated the joint. In a butt braze there shall be no concavity. The braze may be repaired or rebrazed.

PB-49.3 The presence of a crack in the brazing filler metal shall be cause for rejection. Dye penetrant inspection may be used if desired. The braze may be repaired or rebrazed (see PB-33).

PB-49.4 The presence of a crack in the base metal adjacent to a braze shall be cause for rejection even if the crack is filled with brazing alloy. Repair is not permitted.

PB-49.5 Pinholes or open defects in the braze shall be cause for rejection. The joint may be rebrazed.

PB-49.6 Rough fillets, particularly those with a convex appearance, are cause for rejection. Such joints may be repaired or rebrazed.

³ Flux residues can be extremely corrosive as well as interfering with visual inspection.

PB-50 EXEMPTIONS

Certain brazed joints regardless of their service temperatures may be exempt from the additional mechanical testing of this Section providing that the design application does not assume any benefit from the brazed joint strength. It shall however meet the requirements of those qualification tests required by Section IX of the Code (see PB-1.1, Scope).

MARKING AND REPORTS**PB-51 GENERAL**

The provisions for marking and reports given in PG-104 through PG-113 shall apply to brazed boilers and parts thereof.

PART PWT

General		
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PART PWT

REQUIREMENTS

FOR WATERTUBE BOILERS

GENERAL

PWT-1 GENERAL

The rules in Part PWT are applicable to watertube boilers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the special requirements in the applicable Parts of this Section that apply to the method of fabrication used. The rules in Part PWT do not apply to external piping.

MATERIALS

PWT-5 GENERAL

PWT-5.1 Materials used in the construction of pressure parts for watertube boilers shall conform to one of the specifications in Section II and shall be limited to those for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, for Section I construction or as otherwise specifically permitted in Part PG and Part PWT.

PWT-5.2 Mud drums of boilers shall be of either wrought steel or cast steel as designated in SA-216.

DESIGN

PWT-8 GENERAL

The rules in the following paragraphs apply specifically to the design of watertube boilers and parts thereof and shall be used in conjunction with the general requirements for design in Part PG as well as with the specific requirements for design in the applicable Parts of this Section that apply to the method of fabrication used.

PWT-9 TUBES AND PIPE

PWT-9.1 Economizer, boiler generator, and superheater tubes shall comply with the specifications as listed in PG-9.

PWT-9.2 Seamless steel pipe not exceeding NPS 1½ (DN 40) complying with SA-53 or SA-106 may be threaded into the tubesheet, drum, or steel fitting of a watertube boiler. Steel fittings, if used, must fully cover the threads.

PWT-9.3 A tube in which a fusible plug is to be installed shall be not less than 0.22 in. (5.6 mm) in thickness at the plug in order to secure four full threads for the plug. (See also A-20.)

PWT-10 TUBE WALL THICKNESS

PWT-10.1 The minimum tube wall thickness at the maximum allowable working pressure for carbon or alloy steel tubes or nipples subjected to internal pressure for watertube boilers, economizers, and superheaters shall be determined in accordance with PG-27.2.1.

PWT-10.2 Where the outside diameter of a circular boiler pressure part exceeds 5 in. (127 mm), the minimum thickness shall be determined by the formula in PG-27.2.2.

PWT-10.3 For tubes of the materials listed in its title, Table PWT-10 may be used in lieu of the formula for determining the minimum wall thickness of tubes where expanded into drums or headers, provided the maximum mean wall temperature does not exceed 700°F (371°C).

PWT-11 TUBE CONNECTIONS

Tubes, pipe, and nipples may be attached to shells, heads, headers, and fittings by one of the following methods.

TABLE PWT-10
 MAXIMUM ALLOWABLE WORKING PRESSURES FOR SEAMLESS STEEL AND ELECTRIC RESISTANCE WELDED STEEL TUBES OR NIPPLES FOR
 WATERTUBE BOILERS, WHERE EXPANDED INTO DRUMS OR HEADERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO
 THE REQUIREMENTS OF SPECIFICATIONS SA-178 GRADE A, SA-192, AND SA-226

Wall Thickness, in.		Nearest Bwg. No.	Customary Units																		
			Tube Outside Diameter, in.																		
			1/2	3/4	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/2	5	
0.055	17 -		640	380	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
0.065	16		1,170	730	510	440	380	...	...	...	...	...	...	...	...	...	...	...	...	...	...
0.075	15 +		1,730	1,080	770	670	590	470	...	...	...	...	...	...	...	...	...	...	...	...	...
0.085	14 +		...	1,450	1,040	900	800	640	525	442	...	...	...	...	...	...	...	...	...	...	...
0.095	13		...	...	...	2,140	1,900	820	680	580	500	430	380	...	...	...	...	...	...	...	...
0.105	12 -		...	...	...	...	2,130	1,730	1,450	1,240	610	540	480	420	...	...	...	...	...	...	...
0.120	11		...	...	...	...	...	...	1,690	1,450	1,260	1,120	1,000	900	500	460	420	...	...	...	...
0.135	10 +		...	...	...	...	...	...	1,930	1,660	1,450	1,280	1,150	1,040	950	870	800	740	...	...	...
0.150	9 +		...	...	...	...	...	...	2,180	1,870	1,630	1,450	1,300	1,170	1,070	980	900	840	...	...	...
0.165	8		...	...	...	...	...	...	...	2,090	1,820	1,620	1,450	1,310	1,190	1,100	1,010	940	820	720	...
0.180	7		...	...	...	...	...	...	...	...	2,020	1,790	1,600	1,450	1,320	1,210	1,120	1,040	900	800	...
0.200	6 -		...	...	...	...	...	...	...	...	...	2,020	1,810	1,630	1,490	1,370	1,260	1,170	1,020	900	...
0.220	5		...	...	...	...	...	...	...	...	...	...	2,020	1,820	1,660	1,530	1,410	1,310	1,140	1,010	...
0.240	4 +		...	...	...	...	...	...	...	...	...	...	...	2,020	1,840	1,690	1,560	1,450	1,260	1,120	...
0.260	3 +		...	...	...	...	...	...	...	...	...	...	...	...	2,020	1,850	1,710	1,590	1,390	1,230	...
0.280	2 -		...	...	...	...	...	...	...	...	...	...	...	...	2,200	2,020	1,860	1,730	1,510	1,340	...
0.300	...		...	...	...	...	...	...	...	...	...	...	...	...	...	2,180	2,020	1,870	1,630	1,450	...
0.320	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,170	2,020	1,760	1,560	...
0.340	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,160	1,890	1,670	...
0.360	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,020	1,790	...
0.380	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,140	1,900	...
0.400	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,020	...
0.420	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

(continued)

Table PWT-10

2001 SECTION I

TABLE PWT-10 (CONT'D)
 MAXIMUM ALLOWABLE WORKING PRESSURES FOR SEAMLESS STEEL AND ELECTRIC RESISTANCE WELDED STEEL TUBES OR NIPPLES FOR
 WATERTUBE BOILERS, WHERE EXPANDED INTO DRUMS OR HEADERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES CONFORMING TO
 THE REQUIREMENTS OF SPECIFICATIONS SA-178 GRADE A, SA-192, AND SA-226

SI Units																			
Wall Thickness, mm	Nearest Bwg. No.	Tube Outside Diameter, mm																	
		12.7	19	25.4	28.6	31.8	38.1	44.4	50.8	57.2	63.5	69.8	76.2	82.6	88.9	95.2	101.6	114.3	127.0
1.40	17 -	4 413	2 620	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1.65	16	8 067	5 033	3 516	3 034	2 620	...	...	...	...	...	...	...	...	...	...	...	...	...
1.91	15 +	11 928	7 447	5 309	4 620	4 068	3 241	...	...	...	...	...	...	...	...	...	...	...	...
2.16	14 +	...	9 998	7 171	6 206	5 516	4 413	3 620	3 048	...	...	...	...	...	...	...	...	...	...
2.41	13	...	...	...	14 755	13 101	5 654	4 689	3 999	3 448	2 965	2 620	...	...	...	...	...	...	...
2.67	12 -	...	...	...	...	14 686	11 928	9 998	8 550	4 206	3 723	3 310	2 896	...	...	...	...	...	...
3.05	11	...	...	...	...	...	13 928	11 653	9 998	8 688	7 722	6 895	6 206	3 448	3 172	2 896	...	...	...
3.43	10 +	...	...	...	...	...	...	13 307	11 446	9 998	8 826	7 929	7 171	6 550	5 999	5 516	5 102	...	...
3.81	9 +	...	...	...	...	...	...	15 031	12 894	11 239	9 998	8 964	8 067	7 378	6 757	6 206	5 792	5 033	4 413
4.19	8	...	...	...	...	...	...	...	14 411	12 549	11 170	9 998	9 032	8 067	7 585	6 964	6 481	5 654	4 964
4.57	7	...	...	...	...	...	...	...	...	13 928	12 342	11 032	9 998	9 101	8 343	7 722	7 171	6 206	5 516
5.08	6 -	...	...	...	...	...	...	...	...	...	13 928	12 480	11 239	10 274	9 446	8 688	8 067	7 033	6 206
5.59	5	...	...	...	...	...	...	...	...	...	...	13 928	12 549	11 446	10 549	9 722	9 032	7 860	6 964
6.10	4 +	...	...	...	...	...	...	...	...	...	...	...	13 928	12 687	11 653	10 756	9 998	8 688	7 722
6.60	3 +	...	...	...	...	...	...	...	...	...	...	...	...	13 928	12 756	11 790	10 963	9 584	8 481
7.11	2 -	...	...	...	...	...	...	...	...	...	...	...	...	13 928	13 928	12 825	11 928	10 411	9 239
7.62	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15 031	13 928	12 894	11 239	9 998
8.13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14 962	13 928	12 135	10 756
8.64	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14 893	13 032	11 515
9.14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13 928	12 342
9.65	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14 755	13 101
10.16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13 928
10.67	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14 686

GENERAL NOTES:

(a) These values have been calculated by the formula in PG-27.2.1, using allowable stress values at a temperature of 700°F (371°C), from Table 1A of Section II, Part D. Values above the solid line include an additional thickness of 0.04 in. (1.02 mm) to compensate for thinning of tube ends due to the expanding process.

(b) Where calculated allowable working pressures exceeded an even unit of 10 by more than 1, the next higher unit of 10 is given in the table.

PWT-11.1 Tubes may be attached by expanding, flaring, beading, and seal welding in the following combinations illustrated in Fig. PWT-11:

- (a) expanded and flared [sketch (a)];
- (b) expanded and beaded [sketch (b)];
- (c) expanded, flared, seal welded, and re-expanded after welding [sketch (c)]; or
- (d) expanded, seal welded, and re-expanded after welding or seal welded and expanded after welding [sketch (d)].

The end of all tubes that are flared shall project through the tubesheet or header not less than $\frac{1}{4}$ in. (6 mm) nor more than $\frac{3}{4}$ in. (19 mm) before flaring. Where tubes enter at an angle, the maximum limit of $\frac{3}{4}$ in. (19 mm) shall apply only at the point of least projection. Tubes that are expanded and flared without seal welding shall be flared to an outside diameter of at least $\frac{1}{8}$ in. (3.2 mm) greater than the diameter of the tube hole. For tubes that are seal welded, the maximum throat of seal welds shall be $\frac{3}{8}$ in. (10 mm).

PWT-11.2 Superheater, reheater, waterwall, or economizer tubes may be welded to tubular manifolds, headers, or drums and tube ends or weld necks may be welded to drums, all without expanding or flaring, provided the connections comply with the requirements of PW-15 and PW-16. The welds shall be postweld heat treated when required by PG-39.

PWT-11.3 Pipe used for tubes as provided in PWT-9.2 may be attached by threading instead of expanding and flaring, provided the requirements in PG-39.5 are conformed to.

PWT-11.4 Watertubes not exceeding 2 in. (51 mm) O.D. may be welded to tapered ferrules that are attached to the drum by a driven interference fit. In addition to the interference fit, the ferrules shall be held in place by retainer clamps attached to the drum with stud bolts. Fillet welds shall not be used to attach the tubes to the ferrules when exposed to primary furnace gases. Welded stud bolts shall comply with PW-273 and PW-28.6. When tapped holes are provided for the studs, the stud bolts shall comply with PG-39.4. The minimum cross-sectional area of the remaining studs shall be determined by the following equation, but shall not be less than that of a $\frac{3}{8}$ in. (10 mm) stud.

$$A = 0.25\pi D^2 NP/S$$

where

A = the root area of the stud, sq in. (mm²)

S = the allowable stress of the stud material at its design temperature, psi (kPa)

N = the number of fittings retained by the stud

D = the outside diameter of the ferrule at the inside surface of the drum, in. (mm)

P = the design pressure, psi (kPa)

PWT-12 STAYBOLTING BOX TYPE HEADERS

The front and back sheets of staybolted box type headers may be joined together by welding provided:

PWT-12.1 The flat portion in the trough of the header as shown in Fig. PWT-12.1 does not exceed 90% of the allowable staybolt pitch permitted by PG-46, the weld is radiographed, and the welded structure is postweld heat treated; or

PWT-12.2 The inside width of the waterleg does not exceed 4 in. (102 mm), the distance from the weld to the nearest row of staybolts is not more than:

$$(p/2 + r)$$

where

p = pitch permitted by PG-46, in. (mm)

r = radius of waterleg bottom curvature, in. [not to exceed 2 in. (51 mm)]

The design pressure does not exceed 200 psi (1 400 kPa), the welded joint is not exposed to the products of combustion, and the welded structure is postweld heat treated. Radiographic examination is not required.

PWT-13 STAYING SEGMENT OF HEADS

The rules in PFT-25.2 shall be used to determine if staying is required.

PWT-14 FIRING DOORS

A watertube boiler shall have the firing doors of the inward-opening type, unless such doors are provided with substantial and effective latching or fastening devices or otherwise so constructed as to prevent them, when closed, from being blown open by pressure on the furnace side.

These latches or fastenings shall be of the positive self-locking type. Friction contacts, latches, or bolts actuated by springs shall not be used. The foregoing requirements for latches or fastenings shall not apply to coal openings of downdraft or similar furnaces.

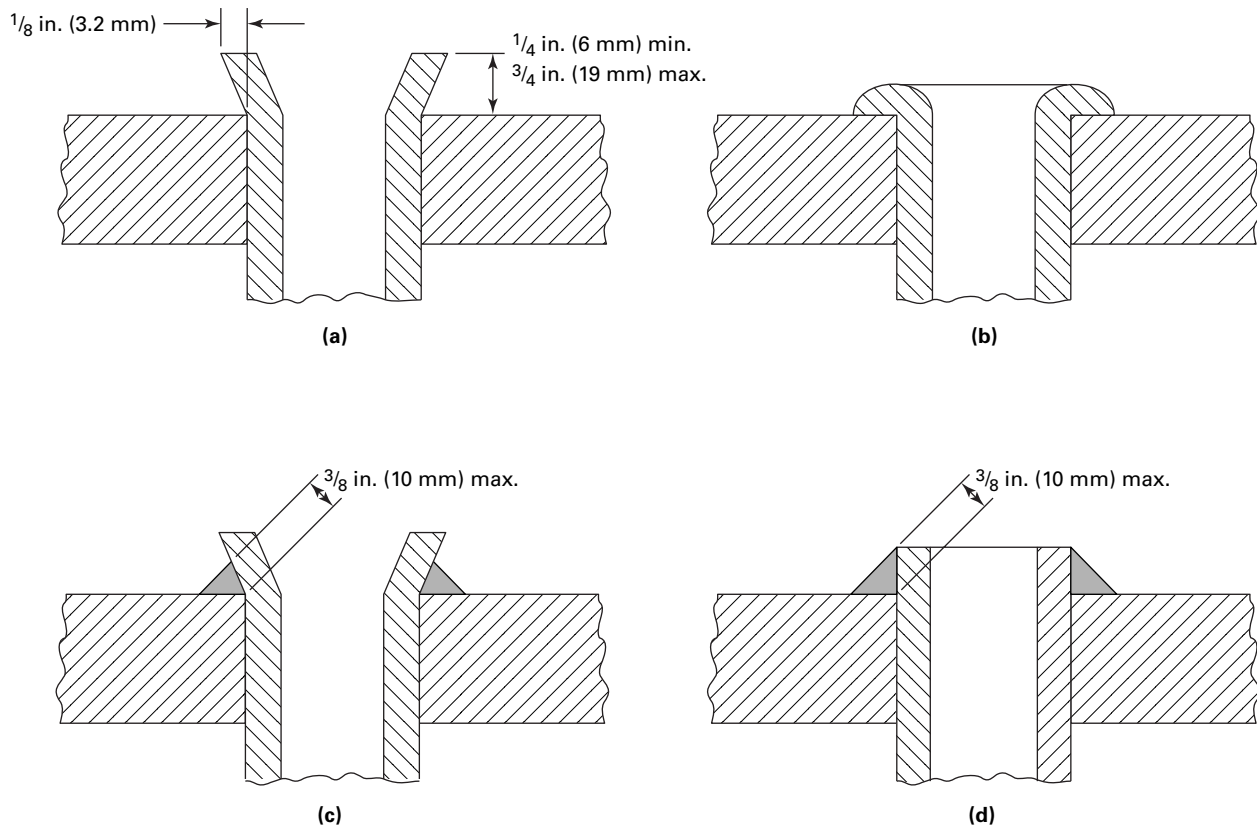


FIG. PWT-11 EXAMPLES OF ACCEPTABLE FORMS OF TUBE ATTACHMENT

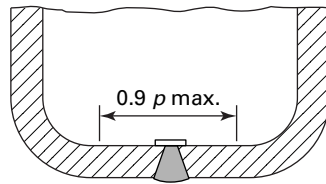


FIG. PWT-12.1 BOX TYPE HEADER JOINT

All other doors, except explosion doors, not used in the firing of the boiler may be provided with bolts or fastenings in lieu of self-locking latching devices.

Explosion doors, if used and if located in the setting walls within 7 ft (2.1 m) of the firing floor or operating platform, shall be provided with substantial deflectors to divert the blast.

01 PWT-15 ACCESS AND FIRING DOORS

The minimum size of an access or fire door opening, in which the minimum furnace dimension is 24 in. (610 mm), shall be not less than 12 in. $\times$ 16 in. (305 mm $\times$ 406 mm) or equivalent area, 11 in. (280 mm) to be the least dimension in any case. A circular opening shall be not less than 15 in. (381 mm) in diameter.

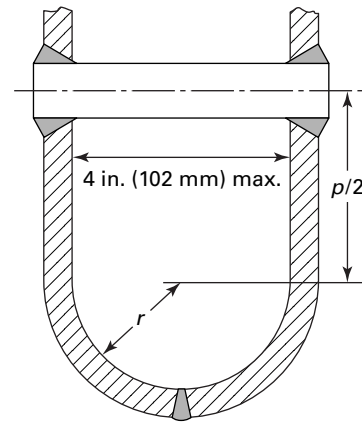


FIG. PWT-12.2 METHOD OF FORMING WATERLEG JOINTS BY WELDING

For furnace dimensions less than 24 in. (610 mm), the opening should be $2\frac{3}{4}$ in. $\times$ $3\frac{1}{2}$ in. (70 mm $\times$ 89 mm) or larger where possible. In cases where the size or shape of the boiler prohibits an opening of that size, two openings with a minimum size of 1 in. (25 mm) may be used, preferably opposite each other, to permit inspection and cleaning of the furnace. If the burner is removable so as to permit inspection and cleaning through the burner opening, a separate access opening need not be provided.

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PART PFT

REQUIREMENTS

FOR FIRETUBE BOILERS

GENERAL

PFT-1 GENERAL

The rules in Part PFT are applicable to firetube boilers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the specific requirements in the applicable Parts of this Section that apply to the method of fabrication used.

MATERIALS

PFT-5 GENERAL

PFT-5.1 Materials used in the construction of pressure parts for firetube boilers shall conform to one of the specifications given in Section II and shall be limited to those for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, or as otherwise specifically permitted in Part PG and Part PFT.

PFT-5.2 Waterleg and doorframe rings of vertical firetube boilers and of locomotive and other type boilers shall be of wrought iron or steel, or cast steel as designated in the SA-216. The ogee or other flanged construction may be used as a substitute in any case.

DESIGN

PFT-8 GENERAL

The rules in the following paragraphs apply specifically to the design of firetube boilers and parts thereof and shall be used in conjunction with the general requirements for design in Part PG as well as with the specific requirements for design in the applicable Parts of this Section that apply to the method of fabrication used.

PFT-9 THICKNESS REQUIREMENTS

PFT-9.1 Shell and Dome. The thickness after forming shall be as determined in accordance with the rules in Part PG but shall not be less than the values shown in the following table.

Inside Diameter of Shell or Dome, in. (mm)	Minimum Thickness, in. (mm)
36 (914) or under	$\frac{1}{4}$ (6.4)
Over 36 (914) to 54 (1 372)	$\frac{5}{16}$ (8.0)
Over 54 (1 372) to 72 (1 829)	$\frac{3}{8}$ (9.5)
Over 72 (1 829)	$\frac{1}{2}$ (12.7)

PFT-9.2 Tubesheet

PFT-9.2.1 The thickness shall be as determined in accordance with Part PG and Part PFT but shall not be less than the values given in the following table.

Inside Diameter of Shell, in. (mm)	Minimum Thickness, in. (mm)
42 (1 067) or under	$\frac{3}{8}$ (9.5)
Over 42 (1 067) to 54 (1 372)	$\frac{7}{16}$ (11.2)
Over 54 (1 372) to 72 (1 829)	$\frac{1}{2}$ (12.7)
Over 72 (1 829)	$\frac{9}{16}$ (14.3)

PFT-9.2.2 When butt welded to the shell of a firetube boiler, a formed tubesheet with a straight flange longer than $1\frac{1}{2}$ times the tubesheet thickness shall have a straight flange thickness not less than that specified in the table in PFT-9.2.1, but in no case less than 0.75 times the thickness of the shell to which it is attached.

PFT-10 SHELL JOINTS

Longitudinal and circumferential welded joints of a shell or drum shall comply with the rules in Part PW.

PFT-11 ATTACHMENT OF HEADS AND TUBESHEETS

Flat heads and tubesheets of firetube boilers shall be attached by one of the following methods.

PFT-11.2 By flanging and butt welding in accordance with Part PG and Part PW.

PFT-11.3 By attaching an outwardly or inwardly flanged tubesheet to the shell by fillet welding provided the following requirements are met.

PFT-11.3.1 The tubesheet is supported by tubes, or stays, or both.

PFT-11.3.2 The joint attaching an outwardly flanged tubesheet is wholly within the shell and forms no part thereof.

PFT-11.3.3 Inwardly flanged tubesheets are full fillet welded inside and outside.

PFT-11.3.4 The throat dimension of the full fillet weld is equal to not less than 0.7 of the thickness of the head.

PFT-11.3.5 The shell at the welds is not in contact with primary furnace gases.¹

PFT-11.3.6 The construction conforms in all other respects to the requirements of this Section, including welding and postweld heat treating, except that radiographic examination is not required.

PFT-11.3.7 This construction shall not be used on the rear head of a horizontal-return tubular boiler and inwardly flanged tubesheets shall not be used on a boiler with an extended shell.

PFT-11.3.8 On inwardly flanged tubesheets, the length of flange shall conform to the requirements of PW-13 and the distance of the outside fillet weld to the point of tangency of the knuckle radius shall be not less than $\frac{1}{4}$ in. (6 mm).

PFT-11.4 By attaching an unflanged tubesheet to the shell by welding provided the following requirements are met.

PFT-11.4.1 The tubesheet is supported by tubes, or stays, or both.

PFT-11.4.2 The welded joint may be made through the tubesheet or shell thickness. When the weld joint is made through the shell, a minimum of 80% of the pressure load shall be carried by the tubes, stays, or both.

¹Primary furnace gases are those in a zone where the design temperature of those gases exceeds 850°F.

PFT-11.4.3 The weld is a full penetration weld equal at least to the full thickness of the base metal applied from either or both sides. When the full penetration weld is made through the shell, an external fillet weld with a minimum throat of $\frac{1}{4}$ in. shall be provided, and no weld prep machining shall be performed on the flat tubesheet. The distance from the edge of the completed weld to the peripheral edge of the tubesheet shall not be less than the thickness of the tubesheet.

PFT-11.4.4 The shell or wrapper sheet, where exposed to primary furnace gases¹ and not water cooled, does not extend more than $\frac{1}{8}$ in. (3.2 mm) beyond the outside face of the tubesheet.

PFT-11.4.5 The weld attaching a furnace or a lower tubesheet of a vertical firetube boiler to the furnace sheet is wholly within the furnace sheet and is ground flush with the upper or water side of the tubesheet.

PFT-11.4.6 The construction conforms in all other aspects to the requirements of this Section including welding, and postweld heat treatment, except that radiographic examination is not required.

PFT-11.4.7 This construction shall not be used on the rear head of a horizontal-return tubular boiler.

PFT-12 TUBES

PFT-12.1 Allowable Working Pressure

PFT-12.1.1 The maximum allowable working pressure of tubes or flues of firetube boilers shall be as given in PFT-50 and PFT-51.

PFT-12.1.2 The maximum allowable working pressure for copper tubes or nipples subjected to internal or external pressure shall not exceed 250 psi (1 720 kPa). The maximum temperature shall not exceed 406°F (208°C).

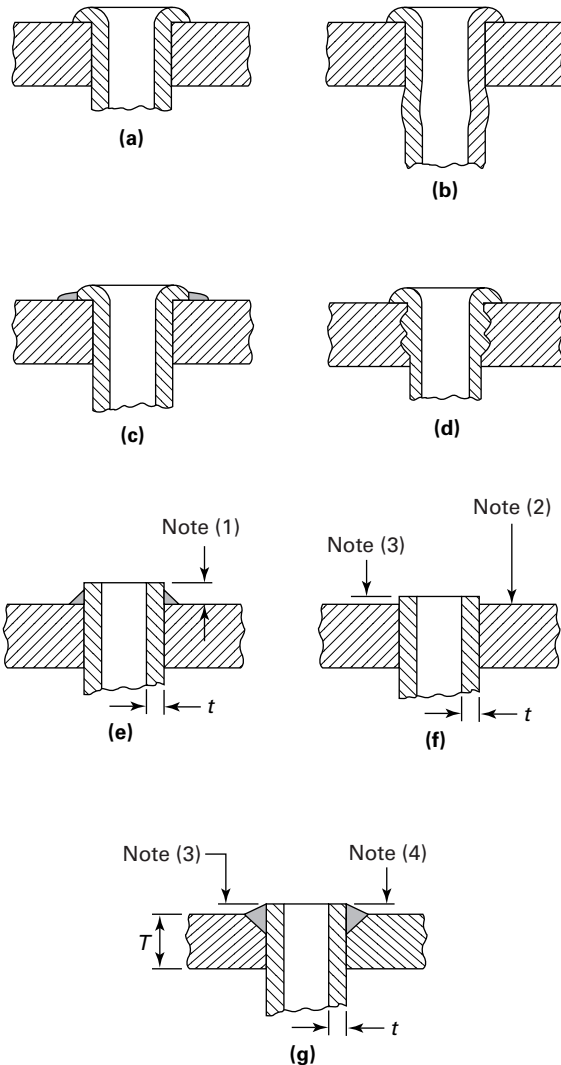
The maximum allowable working pressure for copper-clad tubes subjected to external pressure shall be determined by the formula in PFT-51, in which t may be increased by one-half the thickness of the cladding.

PFT-12.2 Attachment of Tubes

PFT-12.2.1 Figure PFT-12.1 illustrates some of the acceptable types of tube attachments. Such connections shall be:

(a) expanded and beaded as in sketches (a), (b), and (d);

(b) expanded and beaded and seal welded as in sketch (c);



NOTES:

- (1) Not less than t or $1/8$ in. (3.2 mm), whichever is the greater, nor more than $2t$ or $1/4$ in. (6 mm), whichever is the lesser.
- (2) Not less than t or $1/8$ in. (3.2 mm), whichever is the greater, nor more than $T/3$ (see PFT-12.2.1.2).
- (3) Not more than t .
- (4) Not less than t or $1/8$ in. (3.2 mm), whichever is the greater, nor more than $T/3$ (see PFT-12.2.1.2).

FIG. PFT-12.1 SOME ACCEPTABLE FORMS OF
TUBE ATTACHMENT ON FIRETUBE BOILERS

- (c) expanded and seal welded as in sketch (e);
- (d) welded, as in sketches (f) and (g).

Tube ends attached by expanding and welding are subject to the following provisions.

PFT-12.2.1.1 Where no bevel or recess is employed, the tube shall extend beyond the tubesheet not less than a distance equal to the tube thickness or $1/8$ in. (3.2 mm), whichever is the greater, nor more than twice the tube thickness or $1/4$ in. (6 mm), whichever is the lesser [see Fig. PFT-12.1, sketch (e)].

PFT-12.2.1.2 The tubesheet hole may be beveled or recessed. The depth of any bevel or recess shall not be less than the tube thickness or $1/8$ in. (3.2 mm), whichever is greater, nor more than one-third of the tubesheet thickness, except that when tube thicknesses are equal to or greater than 0.150 in. (4 mm), the bevel or recess may exceed $T/3$. Where the hole is beveled or recessed, the projection of the tube beyond the tubesheet shall not exceed a distance equal to the tube wall thickness [see Fig. PFT-12.1, sketches (f) and (g)].

PFT-12.2.1.3 On types of welded attachment shown in Fig. PFT-12.1 sketches (c) and (e), the tubes shall be expanded before and after welding. On types shown in sketches (f) and (g), the tubes may be expanded.

PFT-12.2.2 Expanding of tubes by the Prosser method may be employed in combination with any beaded or seal welded attachment method [see Fig. PFT-12.1, sketch (b)].

PFT-12.2.3 After seal welding as shown by Fig. PFT-12.1 sketches (c) and (e), a single hydrostatic test of the boiler shall suffice.

PFT-12.2.4 The inner surface of the tube hole in any form of attachment may be grooved or chamfered.

PFT-12.2.5 The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

COMBUSTION CHAMBERS

PFT-13 COMBUSTION CHAMBER TUBESHEET

PFT-13.1 The maximum allowable working pressure on a tubesheet of a combustion chamber, where the crown sheet is not suspended from the shell of the boiler, shall be determined by the following formula:

Customary Units

$$P = 27,000 \frac{t(D - d)}{WD}$$

SI Units

$$P = 186\,000 \frac{t(D - d)}{WD}$$

where

P = maximum allowable working pressure, psi (kPa)

D = least horizontal distance between tube centers on a horizontal row, in. (mm)

d = inside diameter of tubes, in. (mm)

t = thickness of tubesheet, in. (mm)

W = distance from the tubesheet to opposite combustion chamber sheet, in. (mm)

Where tubes are staggered the vertical distance between the center lines of tubes in adjacent rows must be not less than

$$1/2 \sqrt{2dD + d^2}$$

Example: Required the maximum allowable working pressure of a tubesheet supporting a crown sheet stayed by crown bars. Horizontal distance between centers, $4\frac{1}{8}$ in.; inside diameter of tubes, 2.782 in.; thickness of tubesheets $\frac{11}{16}$ in.; distance from tubesheet to opposite combustion-chamber sheet, $34\frac{1}{4}$ in.; measured from outside of tubesheet to outside of back plate; material, steel. Substituting and solving:

$$P = \frac{(4.125 - 2.782) \times 0.6875 \times 27,000}{34.25 \times 4.125} = 176 \text{ psi}$$

PFT-13.2 Sling stays may be used in place of girders in all cases covered in PFT-13.1, provided, however, that when such sling stays are used, girders or screw stays of the same sectional area shall be used for securing the bottom of the combustion chamber to the boiler shell.

PFT-13.3 When girders are dispensed with and the top and bottom of combustion chambers are secured by sling stays, the sectional area of such stays shall conform to the requirements of rules for stayed surfaces.

PFT-14 GENERAL

PFT-14.1 Furnaces may be constructed using seamless pipe, electric resistance welded pipe within the limitations of PG-9.5, or fusion welded plate of the double welded butt type. A sample of the longitudinal weld, made with the addition of filler metal, of each section of a furnace shall be subjected to a bend test in accordance with PW-53. No radiography of the longitudinal or circumferential welds is required.

PFT-14.2 When the longitudinal joint will be subjected to complete radiographic examination in accordance with PW-51, the individual bend test for each section of the furnace is not required.

PFT-15 PLAIN CIRCULAR FURNACES

PFT-15.1 Plain circular furnaces may be made up to any length, using sections where desired. The thickness may not be less than $\frac{5}{16}$ in. (8 mm).

PFT-15.2 The maximum allowable working pressure shall be determined in accordance with PFT-51.

PFT-16 ADAMSON TYPE

When plain horizontal flues are made in sections not less than 18 in. (457 mm) in length and not less than $\frac{5}{16}$ in. (8 mm) in thickness:

PFT-16.1 They shall be flanged with a radius measured on the fire side of not less than three times the thickness of the plate, and the flat portion of the flange outside of the radius shall be at least $\frac{1}{2}$ in. (13 mm) plus three times the sum of the plate thickness plus $\frac{5}{16}$ in. (8 mm).

PFT-16.3 The depth of the Adamson ring between the flanges shall be not less than three times the sum of the plate thickness plus $\frac{5}{16}$ in. (8 mm), and the ring shall be welded inside and outside to each flange. The size of the welds shall be $\frac{1}{4}$ in. (6 mm). The fire edge of the ring shall be $\frac{1}{4}$ in. (6 mm) beyond the point of tangency of the flange and the outer edge of the ring shall be $\frac{1}{4}$ in. (6 mm) inside the flanges. See Fig. PFT-16.

PFT-16.4 An Adamson furnace may be assembled by welding, provided the outside edges of the flue flanges are attached to Adamson rings by full fillet welds, inside edges of the rings are welded to the flat portions of the flue flanges by full fillet welds, and the welds are postweld heat treated in accordance with PW-39.

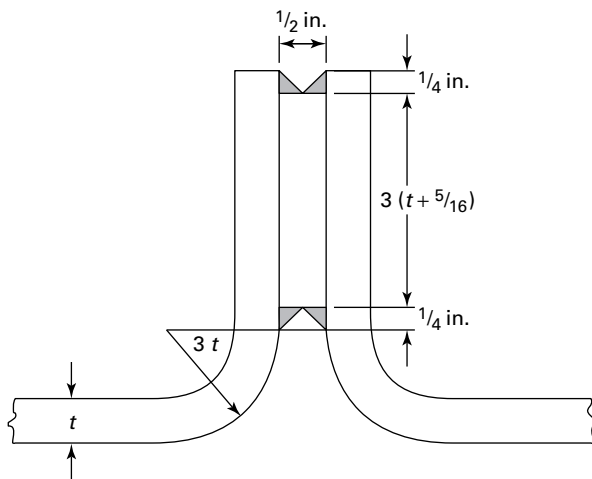


FIG. PFT-16 ADAMSON TYPE FURNACE CONSTRUCTION

PFT-16.5 The maximum allowable working pressure shall be determined in accordance with PFT-51.

PFT-17 RING REINFORCED TYPE

Horizontal cylindrical flues or furnaces (Fig. PFT-17.2) may be constructed with circular stiffening rings provided the following requirements are met.

PFT-17.1 The stiffening ring is rectangular in cross section and is fabricated from one piece of plate, or from plate sections or bars provided full penetration welds are used in assembling.

PFT-17.2 The stiffening ring after fabrication has a thickness of not less than $\frac{5}{16}$ in. (8 mm) and not more than $\frac{13}{16}$ in. (21 mm) and in no case thicker than $1\frac{1}{4}$ times the furnace wall thickness.

PFT-17.3 The ratio of the height of the stiffening ring to its thickness, H_r/T_r , is not greater than 8 nor less than 3.

PFT-17.4 The stiffening ring is attached to the furnace by a full penetration weld on each side.

PFT-17.5 The thickness of the furnace wall or flue is a minimum of $\frac{5}{16}$ in. (8 mm).

PFT-17.6 The spacing L of the rings on the furnace is not greater than $60t$ or 36 in. (914 mm), whichever is smaller.

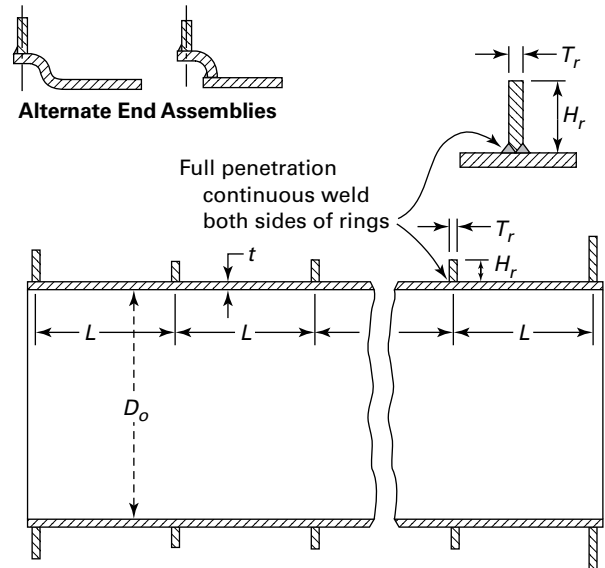


FIG. PFT-17.2 ACCEPTABLE TYPE OF RING REINFORCED FURNACE

PFT-17.8 The boiler design permits replacement of the furnace. A flared or welded ogee ring is an acceptable type of assembly.

PFT-17.10 The maximum allowable working pressure shall be determined in accordance with PFT-51.

PFT-17.11 The design of stiffening rings is determined by the use of the symbols given in PFT-51, and the formula given in this paragraph.

PFT-17.11.1 The moment of inertia for a stiffening ring shall be determined by the following procedure.

Step 1: Assuming that the furnace has been designed and D_o , L_s , and t are known, select a rectangular member to be used for a stiffening ring and determine its area A_s and its moment of inertia I . Then calculate B by the formula:

$$B = \frac{PD_o}{t + (A_s / L_s)}$$

where B = factor on the right-hand side of the applicable chart in Section II, Part D;

Step 2: Enter the right-hand side of the chart at the value of B determined in Step 1;

Step 3: Follow horizontally to the material line for the correct temperature;

Step 4: Move down vertically to the bottom of the chart and read the value of A_s ;

Step 5: Compute the value of the required moment of inertia I_s by the formula:

$$I_s = \frac{D_o^2 L_s [t + (A_s/L_s)] A}{14}$$

Step 6: If the required I_s is greater than the moment of inertia I for the section selected in Step 1, select a new section with a larger moment of inertia and determine a new value of I_s .

If the required I_s is smaller than I for the section selected in Step 1, that section should be satisfactory.

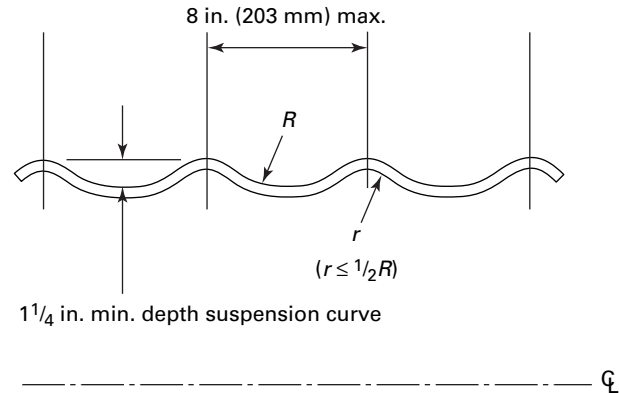


FIG. PFT-18.1 MORISON FURNACE

PFT-18 CORRUGATED FURNACES

PFT-18.1 The maximum allowable working pressure on corrugated furnaces, such as the Leeds suspension bulb, Morison, Fox, Purves, or Brown, having plain portions at the ends not exceeding 9 in. in length (except flues especially provided for), when new and practically circular, shall be computed as follows:

$$P = Ct/D$$

where

P = maximum allowable working pressure, psi (kPa)

t = thickness, in., not less than $\frac{5}{16}$ in. (8 mm) for Leeds, Morison, Fox, and Brown, and not less than $\frac{7}{16}$ in. (11 mm) for Purves furnaces

D = mean diameter, in. (mm)

C = 17,300 (81 000), a constant for Leeds furnaces, when corrugations are not more than 8 in. (203 mm) from center to center and not less than $2\frac{1}{4}$ in. (51 mm) deep

C = 15,600 (107 000), a constant for Morison furnaces, when corrugations are not more than 8 in. (203 mm) from center to center and not less than $1\frac{1}{4}$ in. (32 mm) deep, and the radius of the outer corrugation r , is not more than one-half of the radius of the suspension curve R (see Fig. PFT-18.1)

C = 14,000 (96 000), a constant for Fox furnaces, when corrugations are not more than 8 in. (203 mm) from center to center and not less than $1\frac{1}{2}$ in. (38 mm) deep

C = 14,000 (96 000), a constant for Purves furnaces, when rib projections are not more than 9 in. (230 mm) from center to center and not less than $1\frac{3}{8}$ in. (35 mm) deep

C = 14,000 (96 000), a constant for Brown furnaces, when corrugations are not more than 9 in.

(230 mm) from center to center and not less than $1\frac{5}{8}$ in. (41 mm) deep

In calculating the mean diameter of the Morison furnace, the least inside diameter plus 2 in. (51 mm) may be taken as the mean diameter.

PFT-18.2 The thickness of a corrugated or ribbed furnace shall be ascertained by actual measurement by the furnace manufacturer, by gaging the thickness of the corrugated portions. If a hole is used, the diameter of the hole drilled through the sheet to determine its thickness shall be $\frac{3}{8}$ in. (10 mm). When the furnace is installed the hole shall be located beneath the bottom of the grate and closed by a plug. For the Brown and Purves furnaces, the holes shall be in the center of the second flat; for the Morison, Fox, and other similar types, in the center of the top corrugation, at least as far in as the fourth corrugation from the end of the furnace.

PFT-19 COMBINED PLAIN CIRCULAR AND CORRUGATED TYPE

Combination type furnaces for external pressure may be constructed by combining a plain circular section and a corrugated section provided:

PFT-19.1 Each type of furnace is designed to be self-supporting, requiring no support from the other furnace at their point of connection.

PFT-19.2 Paragraphs PFT-51 and PFT-15 are used for calculating the maximum allowable working pressure of the plain section. In applying the length in the text, or L in the formulas, the value used shall always be twice the actual length of the plain section. The actual

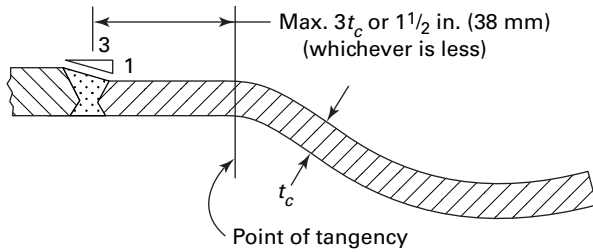


FIG. PFT-19 CONNECTION BETWEEN PLAIN AND CORRUGATED FURNACE

length of the plain section is the distance measured from the center line of the head attachment weld to the center line of the full penetration weld joining the two sections.

PFT-19.3 The maximum allowable working pressure of the corrugated section shall be determined from PFT-18.

PFT-19.4 The full penetration weld joining a plain self-supporting section to a corrugated self-supporting section, shall be located as shown in Fig. PFT-19.

PFT-20 ATTACHMENT OF FURNACES

PFT-20.2 Fillet Welded Construction. In a scotch type boiler, a furnace may be attached to an outwardly flanged opening in a front tubesheet by a circumferential fillet weld, or a furnace may be attached to either tubesheet by flaring the end that extends beyond the outside face of the head to an angle of 20 deg to 30 deg, and using a circumferential fillet weld, provided the following requirements are met.

PFT-20.2.1 The area of the head around the furnace is stayed by tubes, stays, or both in accordance with the requirements of this Section.

PFT-20.2.2 The joint is wholly outside the furnace.

PFT-20.2.3 The throat dimension of the full fillet weld is not less than 0.7 times the thickness of the head.

PFT-20.2.4 Unless protected by refractory material, the furnace does not extend beyond the outside face of the tubesheet a distance greater than the thickness of the tubesheet. Any excess shall be removed before welding.

PFT-20.2.5 The construction conforms in all other respects to the requirements of this Section including

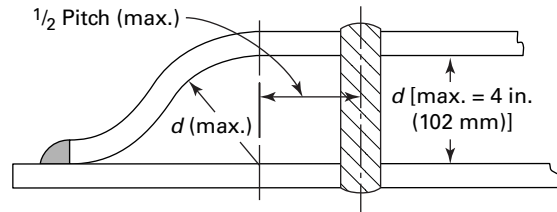


FIG. PFT-20 WELDING OGEE RING

welding and postweld heat treating, except that radiographic examination is not required.

PFT-20.3 Full Penetration Weld Construction. A furnace may be attached by a full penetration weld with the furnace extending at least through the full thickness of the tubesheet but not beyond the toe of the weld, and the toe shall not project beyond the face of the tubesheet by more than $\frac{3}{8}$ in. (10 mm) unless protected from overheating by refractory material or other means.

PFT-20.4 Throat Sheets. Throat sheets and inside and outside front furnace sheets when fully stayed may be attached as required in PFT-11.4.

PFT-20.5 Furnace Sheets Attached by Welding. Vertical firetube boilers may be constructed by welding the ogee bottom of the furnace sheet to the outside shell as shown in Fig. PFT-20 provided the following requirements are met.

PFT-20.5.1 The tube or crown sheet is fully supported by tubes, or stays, or both.

PFT-20.5.2 The joint is wholly within the shell and forms no part thereof.

PFT-20.5.3 The weld is not in contact with primary furnace gases.²

PFT-20.5.4 The throat dimension of the full fillet weld is not less than 0.7 times the thickness of the furnace sheet.

PFT-20.5.5 The maximum depth of the waterleg does not exceed 4 in., and the radius of the ogee is not greater than the inside width of the waterleg.

PFT-20.5.6 The pitch of the lower row of staybolts meets the requirements of PFT-27.5.

PFT-20.5.7 The construction conforms in all other respects to Code requirements including welding and

²Primary furnace gases are those in a zone where the design temperature of those gases exceeds 850°F.

postweld heat treating, except that radiographic examination is not required.

PFT-21 FIREBOXES AND WATERLEGS

PFT-21.1 The width of waterlegs in vertical firetube and firebox boilers shall not exceed the maximum allowable pitch calculated using equation (1) of PG-46, using 2.1 or 2.2 for the value of C depending on the plate thickness. The bottom edges of the plates forming a waterleg may be joined by flanging one or both plates as shown in Fig. PFT-21, sketches (a), (b), and (c). Radiography of the weld joint is not required when the plates being joined form a corner joint, or when the width of the waterleg is limited to 4 in. or less.

PFT-21.2 As an alternative, the bottom edges of the plates forming a waterleg may be joined using a flat plate, or mudring, attached between the waterleg sides as shown in Fig. PFT-21, sketches (d) and (e). The required thickness of the mudring shall be calculated using equation (1) of PG-46, using 2.1 or 2.2 for the value of C , depending on the plate thickness, and a value of p equal to the waterleg inside width, but shall be no less than $\frac{1}{2}$ in. (13mm). Radiography of the joining welds is not required.

- 01 **PFT-21.3** For waterlegs of vertical firetube boilers that are attached to tubesheets or crownsheets, the unstayed distance from a line of support on the tubesheet or crownsheet provided by tubes or stays to the inside surface of the outer wall of the waterleg shall comply with the spacing requirements of PFT-25.2 [see Fig. A-8, sketch (p)].

STAYED SURFACES

PFT-22 GENERAL

The rules of Part PG and Part PW pertaining to stays and stayed surfaces that are applicable to firetube boilers shall be used in conjunction with the following requirements.

PFT-23 WORKING PRESSURE FOR STAYED CURVED SURFACES

PFT-23.1 The maximum allowable working pressure for the surface shall be the sum of the pressure as determined in PFT 23.1.1 and the lesser pressure determined from either PFT-23.1.2 or PFT-23.1.3.

PFT-23.1.1 The maximum working pressure computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of any holes provided for construction.

PFT-23.1.2 The maximum working pressure obtained by the formula given in PG-46 using 1.3 for the value of C .

PFT-23.1.3 The maximum working pressure obtained by the following formula:

$$P_1 = \frac{A_1 S}{A_2}$$

where

P_1 = pressure corresponding to the strength of the stay, psi (kPa)

S = allowable stress of stay as given in Table 1A of Section II, Part D, psi (kPa)

A_1 = cross-sectional area of stay, sq in. (mm²)

A_2 = area supported by stay, sq in. (mm²)

PFT-23.2 The maximum allowable working pressure for a stayed wrapper sheet of a locomotive type boiler shall be the lesser of the values obtained as defined in PFT-23.1 or by the following formula:

Customary Units

$$P = \frac{11,000tE}{R - \Sigma(s \times \sin a)}$$

SI Units

$$P = \frac{75\,000tE}{R - \Sigma(s \times \sin a)}$$

where

P = maximum allowable working pressure, psi (kPa)

t = thickness of wrapper sheet, in. (mm)

E = minimum efficiency of wrapper sheet through joints or stay holes

R = radius of wrapper sheet, in. (mm)

$\Sigma(s \times \sin a)$ = summated value of transverse spacing for all crown stays considered in one transverse plane and on one side of the vertical axis of the boiler

s = transverse spacing of crown stays in the crown sheet, in. (mm)

a = angle any crown stay makes with the vertical axis of boiler

11,000 = allowable stress, psi (kPa)

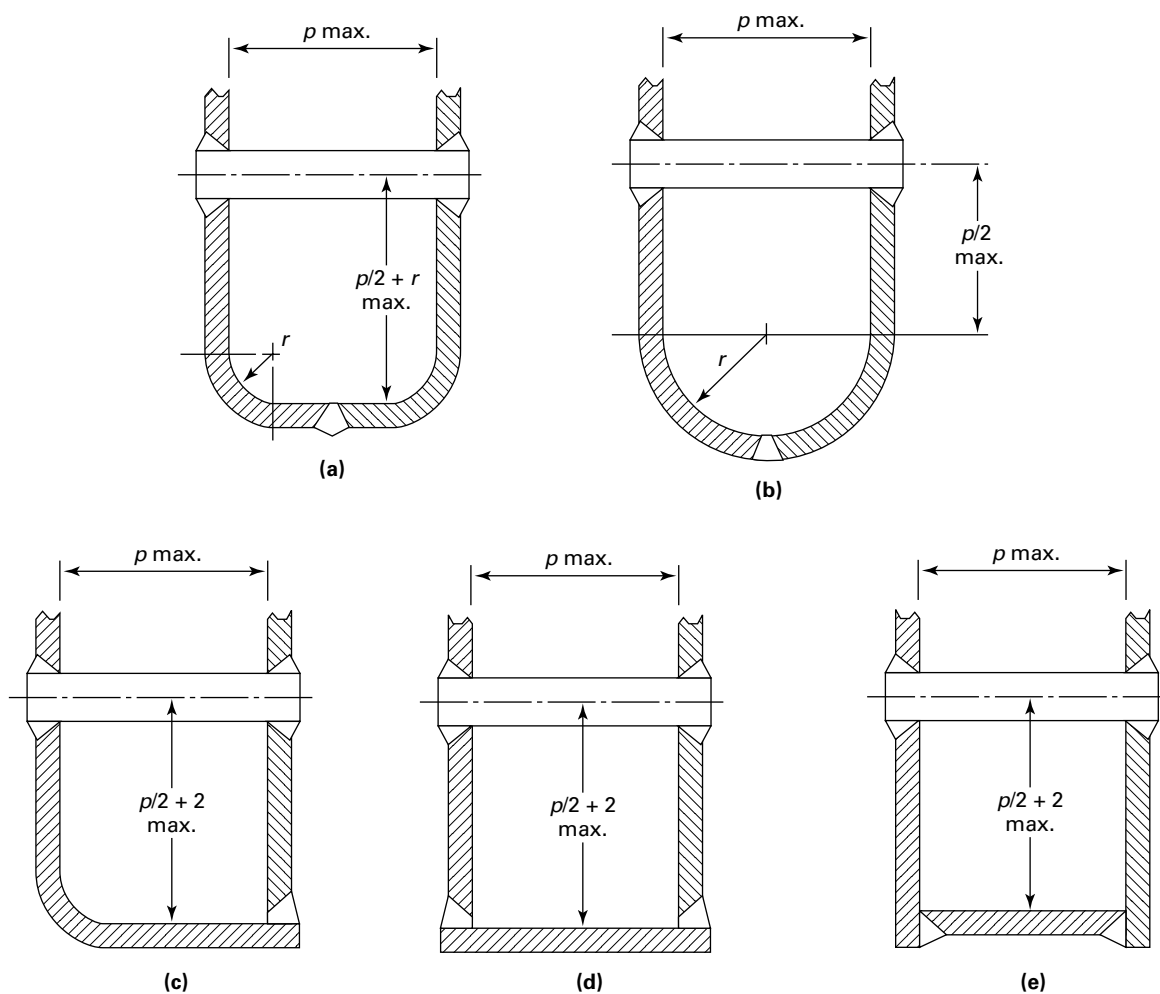


FIG. PFT-21 METHOD OF FORMING WATERLEG JOINTS BY WELDING

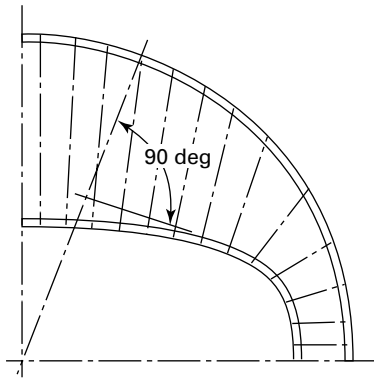


FIG. PFT-23.1 STAYED WRAPPER SHEET OF LOCOMOTIVE TYPE BOILER

The above formula applies to the longitudinal center section of the wrapper sheet, and in cases where E is reduced at another section, the maximum allowable working pressure based on the strength at that section may be increased in the proportion that the distance from the wrapper sheet to the top of the crown sheet at the center bears to the distance measured on a radial line through the other section, from the wrapper sheet to a line tangent to the crown sheet and at right angles to the radial lines (see Fig. PFT-23.1).

PFT-23.3 Furnaces of Vertical Boilers. In a vertical firetube boiler, the furnace length, for the purpose of calculating its strength and spacing staybolts over its surface, shall be measured from the fire side face of flat tubesheets or the point of tangency of flanged tubesheets to the inside of the lower mud ring.

PFT-23.3.1 A furnace for a vertical firetube boiler 38 in. (970 mm) or less in outside diameter that requires staying shall have the furnace sheet supported by one or more rows of staybolts, the circumferential pitch not to exceed 1.05 times that given by the formula in PG-46.

The longitudinal pitch between the staybolts shall not exceed that given by the following formula:

$$L = \left(\frac{56,320t^2}{PR} \right)^2$$

where

- L = longitudinal pitch of staybolts
- P = maximum allowable working pressure, psi (kPa)
- t = thickness of furnace sheet, in. (mm)
- R = outside radius of furnace, in. (mm)

When values by this formula are less than the circumferential pitch, the longitudinal pitch may be as large as the allowable circumferential pitch.

The stress in the staybolts shall not exceed the allowable stress given in Table 1A of Section II, Part D, and determined by PFT-26.1.

PFT-23.3.2 In furnaces over 38 in. (970 mm) in outside diameter and combustion chambers not covered by special rules in this Section which have curved sheets subject to pressure on the convex side, neither the circumferential nor longitudinal pitches of the staybolts shall exceed 1.05 times that given by the rules in PG-46.

PFT-23.4 Upper combustion chambers of vertical submerged tubular boilers made in the shape of a frustrum of a cone when not over 38 in. (970 mm) in outside diameter at the large end may be used without stays if computed by the rule for plain cylindrical furnaces in PFT-14, making D in the formula equal to the outside diameter at the large end, provided that the longitudinal joint conforms to the requirements of PFT-14.

PFT-23.5 For furnaces of PFT 23.4 when over 38 in. (970 mm) in outside diameter at the large end, that portion which is over 30 in. (762 mm) in diameter shall be fully supported by staybolts, and PFT-23.3.2 shall apply. The top row of staybolts shall be at a point where the cone top is 30 in. (762 mm) or less in diameter.

In calculating the pressure permissible on the unstayed portion of the cone, the vertical distance between the horizontal planes passing through the cone top and through the center of the top row of staybolts shall be taken as L in PFT-51. D_o in PFT-51 shall be taken as the inside diameter at the center of the top row of staybolts.

PFT-24 STAYING HORIZONTAL RETURN TUBE BOILERS

When stays are required, the portion of the heads below the tubes in a horizontal-return tubular boiler shall be supported by through-stays attached by welding under PW-19 or with nuts inside and outside at the front head and by attachments which distribute the stress at the rear head.

The distance in the clear between the bodies of the stays or of the inside stays where more than two are used shall not be less than 10 in. (254 mm) at any point.

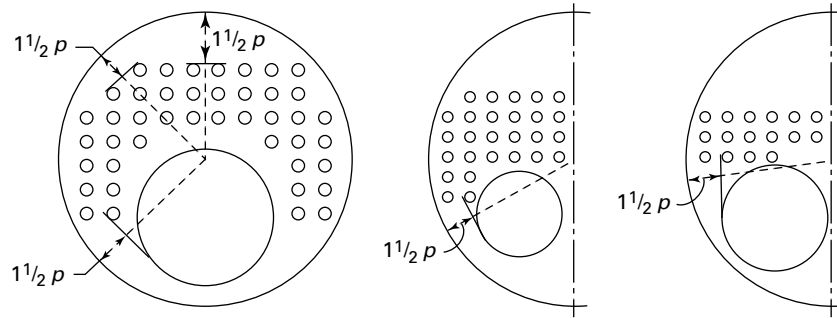


FIG. PFT-25 EXAMPLE OF STAYING OF HEADS
ADJACENT TO CYLINDRICAL FURNACES

PFT-25 STAYING SEGMENTS OF HEADS

PFT-25.1 A segment of a head shall be stayed by head-to-head through stays or diagonal stays.

PFT-25.2 Stays shall be used in the tubesheets of a firetube boiler if the distance between the edges of the tube holes exceeds the maximum pitch of staybolts for the corresponding plate thickness and pressure given in PG-46.

Any part of the tubesheet which comes between the tube or cylindrical furnace and the shell need not be stayed if the greatest distance measured along a radial line from the inner surface of the shell to the center point of tangent to any two tube holes or tube hole and cylindrical furnace on the shell side of such holes does not exceed 1.5 times the value of p obtained by applying the formula of PG-46 with C equal to 1.8 or 1.9 depending upon the plate thickness. The tube holes, or tube hole and cylindrical furnace (see Fig. PFT-25), to which a common tangent may be drawn in applying this rule, shall not be at a greater distance from edge to edge than the maximum pitch referred to.

PFT-26 AREA SUPPORTED BY STAY

PFT-26.1 The full pitch dimensions of the stays shall be employed in determining the area to be supported by a stay, and the area occupied by the stay shall be deducted therefrom to obtain the net area. The product of the net area in square inches by the maximum allowable working pressure in pounds per square inch gives the load to be supported by the stay.

PFT-26.2 Where stays come near the outer edge of the surfaces to be stayed and special allowances are made for the spacing, the load to be carried by such stays shall be determined by neglecting the added area provided for by these special allowances.

Example: If the maximum pitch by PG-46 would make a staybolt come 6 in. (152 mm) from the edge of the plate and a special allowance would make it come 7 in. (178 mm), the distance of 6 in. (152 mm) shall be used in computing the load to be carried.

PFT-27 MAXIMUM SPACING

PFT-27.1 The maximum distance between the edges of tube holes and the centers of stays shall be p as determined by the formula in PG-46, using the value of C given for the thickness of plate and type of stay used.

PFT-27.2 For a flanged head welded to the shell, the maximum distance between the inner surface of the supporting flange and lines parallel to the surface of the shell passing through the center of the stays shall be p as determined by the formula in PG-46, plus the inside radius of the supporting flanges, using the C factor that applies to the thickness of the head plate and type of stay used [see Fig. A-8, sketches (i) and (j)].

PFT-27.3 For unflanged heads, the maximum distance between the inner surface of the shell and the centers of stays shall not be more than one-half the maximum allowable pitch as determined by PG-46, using 2.5 for the value of C , plus 2 in. (51 mm) [see Fig. A-8, sketch (k)].

PFT-27.4 The pitch of diagonal stays attached by welding between the shells and tubesheets of horizontal tubular and scotch boilers, and for other stays when the supported plate is not exposed to radiant heat, as determined by PG-46, may be greater than $8\frac{1}{2}$ in. (216 mm), but shall not exceed 15 times the stay diameter.

PFT-27.5 The pitch of the lower row of staybolts of a vertical firetube boiler, which is required to be stayed by the rules in this Section, and which is fabricated by welding the ogee bottom of the furnace sheet to the outside shell, shall not exceed one-half the maximum allowable pitch as determined by PG-46, measured from the center of the staybolt to the tangent of the ogee (see Fig. PFT-20).

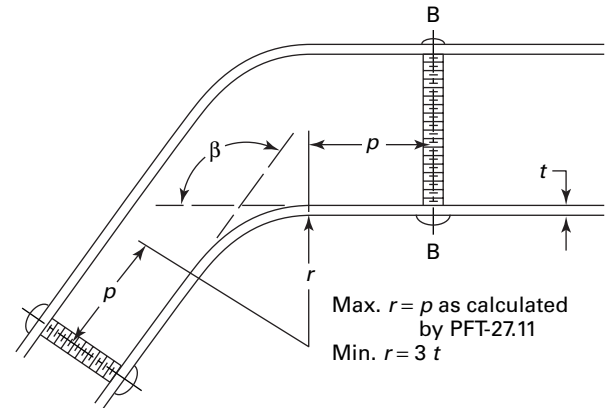
PFT-27.6 The spacing of staybolts around door holes fabricated by fusion welding of the full penetration type of two-flanged sheets, which are required to be stayed by the rules of this Section (see Fig. PWT-12.2), shall not exceed one-half the maximum allowable pitch determined by PG-46, measured from the center of the staybolt to the points of tangency of the flanges.

PFT-27.7 If the furnace sheets are required to be stayed by the rules of this Section, the spacing of staybolts around door holes and the spacing of the first row of staybolts from the bottom of a mud ring fabricated by fusion welding of the full penetration type when either or both sheets are not flanged [see Fig. A-8, sketches (1), (m), and (n)] shall not exceed one-half the maximum pitch determined by PG-46, plus 2 in. (51 mm), measured from the center of the staybolt to the root of the weld.

PFT-27.8 The maximum distance from the first row of stays to a full penetration weld in compression applied from either or both sides of the tubesheet, attaching the crown sheet of a furnace or combustion chamber to a stayed head or tubesheet shall not exceed the pitch determined by PG-46, measured from the center of the stay to the furnace or combustion chamber side of the head or tubesheet [see Figs. A-8, sketches (o) and (p)].

PFT-27.9 When a flanged-in manhole opening with a flange depth of not less than three times the required thickness of the head, or when an unflanged manhole ring meeting the requirements of PG-32 through PG-39 is provided in a flat stayed head of a firetube boiler, as shown in Fig. A-8, sketches (q) and (r), the load created by the unsupported area of the manway shall be supported by the stays surrounding the manway. When the manway is in close proximity to the shell, the load may be shared by the shell by reducing the area supported by the stays by 100 sq in. (64 500 mm²), provided both the following requirements are met.

PFT-27.9.1 The distance between the manhole opening and the inside of the shell does not exceed one-half the maximum allowable pitch for an unflanged manhole and one-half the maximum allowable pitch



GENERAL NOTE: If the radius r exceeds the pitch, the curved plate shall be stayed as a flat plate in accordance with PG-46.

FIG. PFT-27 PITCH OF STAYBOLTS ADJACENT TO UPPER CORNERS OF FIREBOXES

plus the radius of the head flange for a flanged-in manhole in a flanged head.

PFT-27.9.2 The distance between the centers of the first row of stays, or the edges of tube holes, and the manhole opening does not exceed one-half the maximum allowable pitch as determined by PG-46.

PFT-27.10 In applying these rules and those in PG-46 to a head or plate having a manhole or reinforced opening, the spacing applies only to the plate around the opening and not across the opening.

PFT-27.11 For stays at the upper corners of fireboxes, the pitch from the staybolt next to the corner to the point of tangency to the corner curve shall be (see Fig. PFT-27):

$$p = \left[\frac{90}{\text{Angularity of tangent lines } (\beta)} \right] \sqrt{C \frac{t^2 S}{P}}$$

where

t = thickness of plate, in.

S = maximum allowable stress value given in Table 1A of Section II, Part D, psi

P = maximum allowable working pressure, psi

C = factor for the thickness of plate and type of stay used as required in PG-46

β = angle, deg

PFT-28 STAYBOLTS AND STAYS

PFT-28.1 The required area at the point of least net cross section of staybolts and stays shall be as given in PG-49. The maximum allowable stress per square inch at point of least net cross-sectional area of staybolts and stays shall be given as in Table 1A of Section II, Part D. In determining the net cross-sectional area of drilled or hollow staybolts, the cross-sectional area of the hole shall be deducted.

PFT-28.2 The length of the stay between supports shall be measured from the inner faces of the stayed plates. The stresses are based on tension only. For computing stresses in diagonal stays, see PFT-32.

PFT-28.3 When stay rods are screwed through sheets and riveted over, they shall be supported at intervals not to exceed 6 ft (1.8 m). Stay rods over 6 ft (1.8 m) in length may be used without support if fitted with nuts and washers or attached by welding under PW-19, provided the least cross-sectional area of the stay rod is not less than that of a circle 1 in. (25 mm) in diameter and the requirements of PG-46.8 are met.

PFT-29 FLEXIBLE STAYBOLTS

Flexible type staybolts having a cover cap welded under the provisions of PW-15 to the outer sheet may be used in the construction of locomotive type boilers provided the bolts are hollow-drilled from the threaded end into and partly through the ball head to allow for proper inspection, and so that any breakage is disclosed by leakage at the inner end. These welded joints need not be postweld heat treated or radiographed.

PFT-30 CROWN BARS AND GIRDER STAYS

PFT-30.1 Crown bars and girder stays for tops of combustion chambers and back connections, or wherever used, shall be proportioned to conform to the following formula:

$$P = \frac{Cd^2t}{(W-p)D_1W}$$

where

W = extreme distance between supports of, in a scotch marine boiler, the distance from the fire side of the tubesheet to the fire side of the back connection plate, in.

P = maximum allowable working pressure, psi

p = pitch of supporting bolts, in.

D_1 = distance between girders from center to center, in.

d = depth of girder, in.

t = thickness of girder, in.

$C = 7,000$ (48 000) when girder is fitted with one supporting bolt

$C = 10,000$ (69 000) when the girder is fitted with two or three supporting bolts

$C = 11,000$ (75 000) when the girder is fitted with four or five supporting bolts

$C = 11,500$ (79 000) when the girder is fitted with six or seven supporting bolts

$C = 12,000$ (82 000) when the girder is fitted with eight or more supporting bolts

Example: Given $W=34$ in., $p=7.5$ in., $D_1=7.75$ in., $d=7.5$ in., $t=2$ in.; three stays per girder, $C=10,000$; then substituting in formula:

$$P = \frac{10,000 \times 7.5 \times 7.5 \times 2}{(34 - 7.5) \times 7.75 \times 34} = 161.1 \text{ psi}$$

Sling stays, if used between crown bars and boiler shell or wrapper sheet, shall be proportioned so as to carry the entire load without considering the strength of the crown bars.

PFT-30.2 In a form of reinforcement for crown sheets where the top sheet of the firebox is a semicircle and the top part of the circle not exceeding 120 deg in arc is reinforced by arch bars extending over the top and down below the top row of staybolts at the sides of the furnace beneath the semicircular crown sheet, the maximum allowable working pressure shall be determined by adding to the maximum allowable working pressure for a plain circular furnace of the same thickness, diameter, and length determined by the formula in PFT-51, the pressure P_1 determined from the following formula which is a modification of the formula in PFT-23:

Customary Units

$$P_1 = 10,000,000 \frac{bd^3}{D_1 D^3}$$

SI Units

$$P_1 = 69\,000\,000 \frac{bd^3}{D_1 D^3}$$

where

b = net width of crown bar, in.

d = depth of crown bar, in.

D_1 = longitudinal spacing of crown bar that shall not exceed twice the maximum allowable staybolt pitch, in.

D = two times the radius of the crown sheet, in.

provided that the maximum allowable working pressure must not exceed that determined by the formula for furnaces of the Adamson type, in PFT-51 when L is made equal to D_1 , and also provided that the diameter of the holes for the staybolts in the crown bars does not exceed $\frac{1}{3}b$, and the cross-sectional areas of the crown bars is not less than 4 sq in. (2581 mm²). PG-46 governs the spacing of the staybolts or bolts attaching the sheet to the bars, and PFT-28, the size of the staybolts or bolts.

For constructions in which the crown sheet is not semicircular, or in which other features differ from those specified above, a test shall be made in accordance with PG-100 and the working pressure shall be based thereon.

PFT-30.3 Cast iron supporting lugs, legs, or ends shall not be used.

PFT-31 STAY TUBES

PFT-31.1 When tubes are used as stays in multitubular boilers to give support to the tubesheets, the required cross-sectional area of such tubes shall be determined in accordance with PG-49.

PFT-31.2 The required tubesheet thickness and maximum pitch of stay tubes shall be calculated using the following equations:

$$t = \sqrt{\frac{P}{CS} \left(p^2 - \frac{\pi d^2}{4} \right)}$$

$$p = \sqrt{\frac{CS t^2}{P} + \frac{\pi d^2}{4}}$$

where

t = required thickness of tubesheet, in. (mm)

p = maximum pitch measured between the centers of tubes in different rows, which may be horizontal, vertical, or inclined, in. (mm)

C = 2.1 for tubesheets not over $\frac{7}{16}$ in. (11 mm) thick
= 2.2 for tubesheets over $\frac{7}{16}$ in. (11 mm) thick

S = maximum allowable stress value for the tubesheet material given in Table 1A of Section II, Part D, psi (kPa)

P = design pressure, psi (kPa)

d = outside diameter of the tube, in. (mm)

PFT-31.3 No calculation need be made to determine the availability of the required cross-sectional area or the maximum allowable pitch for tubes within or on

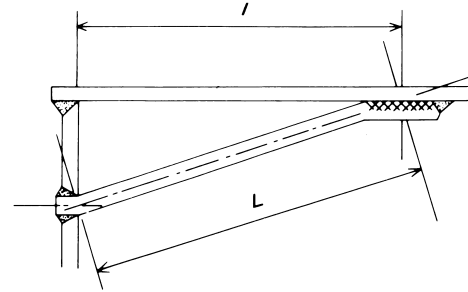


FIG. PFT-32 MEASUREMENTS FOR DETERMINING STRESSES IN DIAGONAL STAYS

the perimeter of a nest of tubes that are spaced at less than twice their average diameter.

PFT-31.4 Stay tubes may be attached by any of the acceptable means shown in Fig. PFT-12.1.

PFT-32 STRESSES IN DIAGONAL STAYS

PFT-32.1 To determine the required area of a diagonal stay, multiply the area of a direct stay required to support the surface by the slant or diagonal length of the stay; and divide this product by the length of a line drawn at right angles to surface supported to center of palm of diagonal stay, as follows:

$$A = aL/l$$

where

A = sectional area of diagonal stay, sq in. (mm²)

a = sectional area of direct stay, sq in. (mm²)

L = length of diagonal stay as indicated in Fig. PFT-32, in. (mm)

l = length of line drawn at right angles to boiler head or surface supported to center of palm of diagonal stay, as indicated in Fig. PFT-32, in. (mm)

Example: Given diameter of direct stay = 1 in., a = 0.7854 sq in., L = 60 in., l = 48 in.; substituting and solving:

$$A = (0.7854 \times 60) / 48$$

$$= 0.98 \text{ sectional area, sq in.}$$

$$\text{Diameter} = 1.11 \text{ in.}$$

$$= 1\frac{1}{8} \text{ in.}$$

PFT-32.2 For staying segments of tubesheets such as in horizontal-return tubular boilers, where L is not

more than 1.15 times l for any stay, the stays may be calculated as direct stays allowing 90% of the allowable stress value given in Table 1A of Section II, Part D.

DOORS AND OPENINGS

PFT-40 WELDED DOOR OPENINGS

Arc or gas welding may be used in the fabrication of door holes provided the sheets are stayed around the opening in accordance with the requirements of PFT-27.6 and PFT-27.7.

The fit-up of the several parts of an arc or gas welded door opening shall be such that the maximum gap between the two plates to be joined by welding does not exceed $\frac{1}{8}$ in. (3.2 mm).

PFT-41 OPENINGS IN WRAPPER SHEETS

Openings located in the curved portion of the wrapper sheet of a locomotive type boiler shall be designed in accordance with the rules in PG-32.

01 PFT-42 FIRESIDE ACCESS OPENINGS

The minimum size of an access or fire door opening, in which the minimum furnace dimension is 24 in. (610 mm), shall be not less than 12 in. $\times$ 16 in. (305 mm $\times$ 406 mm) or equivalent area, 11 in. (280 mm) to be the least dimension in any case. A circular opening shall be not less than 15 in. (381 mm) in diameter.

For furnace dimensions less than 24 in. (610 mm), the opening should be $2\frac{3}{4}$ in. $\times$ $3\frac{1}{2}$ in. (70 mm $\times$ 89 mm) or larger where possible. In cases where the size or shape of the boiler prohibits an opening of that size, two openings with a minimum size of 1 in. (25 mm) may be used, preferably opposite each other, to permit inspection and cleaning of the furnace. If the burner is removable so as to permit inspection and cleaning through the burner opening, a separate access opening need not be provided.

The bonnet or smoke hood of a vertical flue or tubular boiler shall be provided with an access opening at least 6 in. $\times$ 8 in. (152 mm $\times$ 203 mm) for the purpose of inspection and cleaning the top head of the boiler.

PFT-43 REQUIREMENTS FOR INSPECTION OPENINGS

PFT-43.1 All openings shall meet the requirements of PG-32 through PG-44. Manholes may be substituted for handholes. Where washout plugs are used the minimum size shall be $1\frac{1}{2}$ in. (38 mm).

PFT-43.2 Horizontal-Return Tubular Boiler. A manhole shall be provided in the front head below the tubes. On boilers less than 48 in. (1 200 mm) in inside diameter a handhole may be used in lieu of the manhole. A manhole shall be provided in the upper part of the shell or head. On boilers 40 in. (1 000 mm) and under in inside diameter a handhole may be used in lieu of the manhole.

PFT-43.3 Traction, Stationary, or Portable Return Tube Firetube Boilers. Handholes or washout plugs, not less than six, shall be located as follows: one in the rear head below the tubes; four in the lower part of the waterleg, with one near the throat sheet when possible; one in the front head at the line of the crown sheet, except when the location would lie within a smoke box the handhole or washout plug shall be located on a side sheet.

Horizontal firetube boilers shall also have a manhole located above the tubes on the head or shell, except that on boilers 48 in. (1 200 mm) and under in inside diameter a handhole may be used in lieu of the manhole.

PFT-43.4 Scotch Boilers. Handholes or washout plugs, not less than four, shall be located as follows: one on the bottom of the shell; one above the furnace; one on each side of the front head or shell below the tubes and near the front head.

A manhole shall also be provided on the head or shell above the tubes, except on boilers 48 in. (1 200 mm) and under in inside diameter a handhole may be used in lieu of the manhole.

Scotch marine boilers (wet-back type) shall also have an opening for inspection of the water space at the rear of the combustion chamber.

PFT-43.5 Vertical Boilers

PFT-43.5.1 For sizes over 24 in. (610 mm) in outside diameter the following handholes, not less than four, shall be provided: one at or about the waterline (or opposite the fusible plug when used); three at or about the line of the lower tubesheet.

On internally fired types, three additional handholes shall be provided at the lowest part of the waterleg.

On flueless types, three handholes shall be provided at the bottom of the waterleg in lieu of the three required above.

On submerged tube types, two additional handholes shall be provided in line with the underside of the upper tubesheet.

PFT-43.5.2 For sizes under 24 in. (610 mm) in outside diameter, the following inspection openings, not less than three, shall be provided in the shell: one handhole at the waterline; two washout plugs near the bottom (the blowoff opening shall not be considered in lieu of this requirement).

On internally fired types, a handhole shall be provided in line with the lower tubesheet, in which case the handhole at the waterline may be omitted.

On flueless types, one additional washout plug shall be provided above and adjacent to the firing door.

On submerged tube types, a handhole shall also be provided in line with the upper tubesheet.

PFT-44 OPENING BETWEEN BOILER AND SAFETY VALVE

The opening or connection between the boiler and the safety valve shall have at least the area of the valve inlet.

After the boiler Manufacturer provides for the opening required by the Code, a bushing may be inserted in the opening in the shell to suit a safety valve that will have the capacity to relieve all the steam that can be generated in the boiler and which will meet the Code requirements.

No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, or on the discharge pipe between the safety valve or safety relief valve and the atmosphere. When a discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets discharging therein and shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

DOMES

PFT-45 REQUIREMENTS FOR DOMES

PFT-45.1 The longitudinal joint of a dome may be butt welded or the dome may be made without a seam of one piece of steel pressed into shape. The dome flange may be double full fillet lap-welded to the shell if all welding complies fully with the requirements for welding in Part PW. Radiographic examination of the

fillet welds may be omitted. The opening shall be reinforced in accordance with PG-32 through PG-44.

PFT-45.3 When a dome is located on the barrel of a locomotive type boiler or on the shell of a horizontal-return tubular boiler, the outside diameter of the dome shall not exceed six-tenths the inside diameter of the shell or barrel of the boiler unless the portion of the barrel or shell under the dome (the neutral sheet) is stayed to the head or shell of the dome by stays which conform in spacing and size to the requirements given in PG-46 and Table 1A of Section II, Part D. With such stayed construction the outside diameter of a dome located on the barrel or shell of a boiler is limited to eight-tenths of the barrel or shell inside diameter.

PFT-45.4 All domes shall be so arranged that any water can drain back into the boiler.

PFT-45.5 Flanges of domes shall be formed with a corner radius, measured on the inside, of at least twice the thickness of the plate for plates 1 in. (25 mm) in thickness or less, and at least three times the thickness of the plate for plates over 1 in. (25 mm) in thickness.

PFT-45.6 Domes and manhole frames attached to shells or heads of boilers shall be designed in accordance with PG-32 through PG-44.

PFT-45.7 In a locomotive type boiler with a dome on a tapered course, the maximum allowable diameter of the dome shall be based on that diameter of the tapered course which intersects the axis or center line of the dome.

SETTING

PFT-46 METHOD OF SUPPORT

PFT-46.1 The design and attachment of lugs, hangers, saddles, and other supports shall meet the requirements of PG-22.1 and PG-55.

PFT-46.2 In applying the requirements of PFT-46.1, localized stresses due to concentrated support loads, temperature changes, and restraint against dilation of the boiler due to pressure shall be provided for. Lugs, brackets, saddles, and pads shall conform satisfactorily to the shape of the shell or surface to which they are attached or with which they are in contact.

PFT-46.3 A horizontal-return tubular boiler over 72 in. (1 800 mm) in diameter shall be supported from steel hangers by the outside-suspension type setting, independent of the furnace side walls.

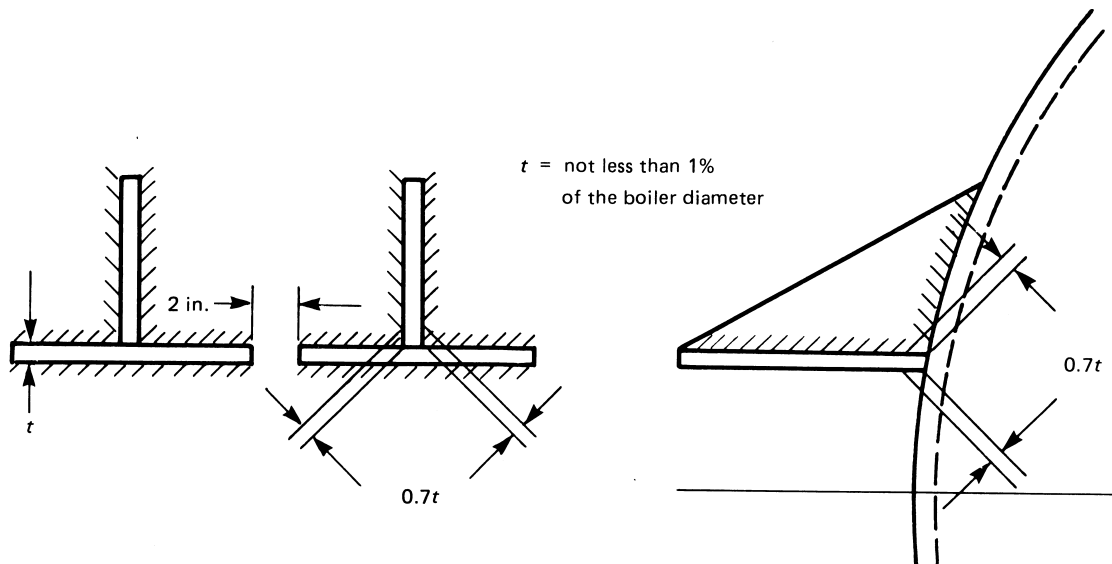


FIG. PFT-46.1 SPACING AND WELD DETAILS FOR WALL-SUPPORT LUGS SET IN PAIRS ON HORIZONTAL-RETURN TUBULAR BOILERS

PFT-46.4 A horizontal-return tubular boiler, 14 ft (4.3 m) or more in length, or over 54 in. (1 400 mm) and up to and including 72 in. (1 800 mm) in diameter, shall be supported by the outside-suspension type of setting as specified in PFT-46.3, or, for wall-supported boilers, at four points by not less than eight steel lugs set in pairs. A horizontal-return tubular boiler up to and including 54 in. (1 400 mm) in diameter shall be supported by the outside-suspension type of setting as specified in PFT-46.3, or, for wall-supported boilers, by not less than two steel lugs on each side. If more than four lugs are used on wall-supported boilers, they shall be set in four pairs, the lugs of each pair to be spaced not over 2 in. (51 mm) apart and the load to be equalized between them (see Fig. PFT-46.1). If the boiler is supported on structural steel work, the steel supporting members shall be so located that heat from the furnace cannot impair their strength.

PFT-46.5 Figure PFT-46.2 illustrates an acceptable design of hanger bracket for welded attachment to welded horizontal-return tubular boilers with the additional requirement that the hanger pin be located at the vertical center line over the center of a welded contact surface. The bracket plates shall be spaced at least $2\frac{1}{2}$ in. (64 mm) apart, but this dimension shall be increased if necessary to permit access for the welding operation.

PFT-46.6 Wet-bottom stationary boilers shall be supported so as to have a minimum clearance of 12 in. (305 mm) between the underside of the wet-bottom and the floor to facilitate inspection. Other types of firetube boilers set horizontally shall be supported so that they have a minimum clearance of 12 in. (305 mm) between the metal surface of the shell and the floor. Boiler insulation, saddles, or other supports shall be arranged so that inspection openings are readily accessible.

PIPING, FITTINGS, AND APPLIANCES

PFT-47 WATER GLASSES

Boilers of the horizontal firetube type shall be so set that when the water is at the lowest reading in the water gage glass there shall be at least 3 in. (76 mm) of water over the highest point of the tubes, flues, or crown sheet.

PFT-48 FEED PIPING

PFT-48.1 When a horizontal-return tubular boiler exceeds 40 in. (1 000 mm) in diameter, the feedwater shall discharge at about three-fifths the length from the

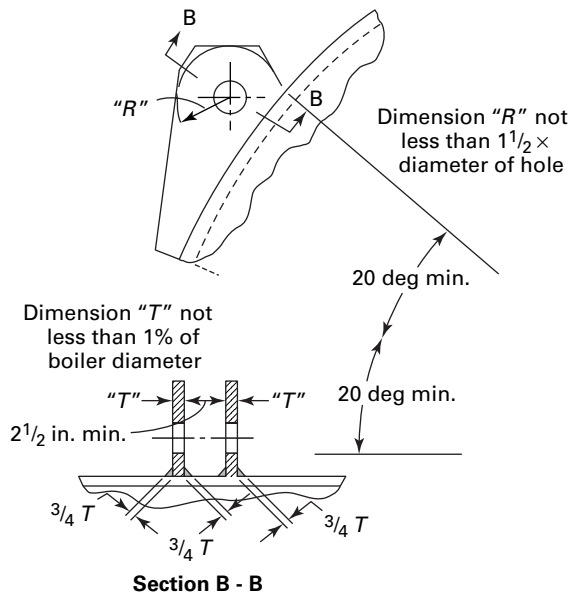


FIG. PFT-46.2 WELDED BRACKET CONNECTION FOR HORIZONTAL-RETURN TUBULAR BOILERS

end of the boiler that is subjected to the hottest gases of the furnace (except a horizontal-return tubular boiler equipped with an auxiliary feedwater heating and circulating device), above the central rows of tubes. The feed pipe shall be carried through the head or shell farthest from the point of discharge of the feedwater in the manner specified for a surface blowoff in PG-59.3.2, and be securely fastened inside the shell above the tubes.

PFT-48.2 In vertical tubular boilers the feedwater shall be introduced at a point not less than 12 in. (305 mm) above the crown sheet. When the boiler is under pressure, feedwater shall not be introduced through the openings or connections used for the water column or gage glass. In closed systems the water may be introduced through any opening when the boiler is not under pressure.

PFT-49 BLOWOFF PIPING

PFT-49.1 Blowoff piping of firetube boilers which is exposed to products of combustion shall be attached by screwing into a tapped opening with provisions for a screwed fitting or valve at the other end.

PFT-49.2 Blowoff piping of firetube boilers which is not exposed to products of combustion may be

attached by any method provided in this Section except by expanding into grooved holes.

PFT-50 THICKNESS OF FURNACES AND TUBES UNDER EXTERNAL PRESSURE

PFT-50.1 Design Temperature shall not be less than the maximum expected mean wall temperature established by calculation or measurement. As an alternative to calculating or measuring the maximum expected mean metal temperature, 700°F (371°C) may be used as the design temperature.³

PFT-50.1.1 Temperatures in excess of the maximum temperature listed for each material given in Tables 1A and 1B of Section II, Part D, are not permitted.

PFT-50.1.2 Temperatures in excess of the maximum temperature given on the external pressure charts are not permitted.

PFT-50.1.3 Rounding off equation results to the next higher unit of 10 is permitted. (See PG-27.4, Note 8.)

PFT-51 MAXIMUM ALLOWABLE WORKING PRESSURE

PFT-51.1 The maximum allowable working pressure of tubes, flues, plain circular, Adamson, and ring reinforced furnaces of firetube boilers shall be as determined by the following rules. External pressure charts for use in determination of minimum requirements are given in Section II, Part D, Subpart 3. Figure numbers shown in this Article are contained in that Subpart.

PFT-51.1.1 The symbols defined below are used in the procedures of this Article:

A = factor determined from Fig. G and used to enter the applicable material chart in Section II, Part D. For the case of cylinders having D_o/t values less than 10, see PFT-51.1.2(b).

B = factor determined from the applicable material chart in Section II, Part D, for maximum design metal temperature, psi (kPa)

D_o = outside diameter of cylindrical furnace or tube, in. (mm)

³The designer is cautioned that the actual maximum mean metal temperature is dependent on the heat input to the furnace, the fuel type, and the design pressure. 700°F (371°C) may not be appropriate for higher design pressures resulting in furnaces over 1 in. (25 mm) thick, or for furnaces with high heat inputs.

E = modulus of elasticity of material at design temperature, psi (MPa) (For this value see the applicable materials chart in Section II, Part D. Interpolation may be made between the lines for intermediate temperatures.)

L = total length, in. (mm), of a furnace or tube between tubesheets, or design length of a furnace taken as the largest of the following:

(a) the greatest center-to-center distance between any two adjacent stiffening rings;

(b) the distance between the tubesheet and the center of the first stiffening ring (Adamson or ring reinforced);

(c) the distance from the center of the first stiffening ring to a circumferential line on a formed head at one-third the depth from the head tangent line.

L_s = one-half of the distance from the center line of the stiffening ring to the next line of support on one side, plus one-half of the center line distance to the next line of support on the other side of the stiffening ring, both measured parallel to the axis of the cylinder, in. (mm). A line of support is:

(a) a stiffening ring that meets the requirements of PFT-17.11;

(b) a circumferential connection to a tubesheet or jacket for a jacketed section of a cylindrical shell;

(c) a circumferential line on a formed head at one-third the depth of the head from the head tangent line.

I_s = required moment of inertia of stiffening ring about its neutral axis parallel to the axis of the furnace, in.⁴ (m⁴)

A_s = cross-sectional area of stiffening ring, sq in. (m²)

P = external design pressure, psi (kPa)

P_a = calculated value of allowable external working pressure for the assumed value of t , psi (kPa)

S = the maximum allowable stress value at design metal temperature, psi (MPa)

t = minimum required thickness of cylindrical furnaces or tubes, in. (mm)

t_s = nominal thickness of cylindrical furnace or tubes, in. (mm)

PFT-51.1.2 Cylindrical Furnaces and Tubes. The required minimum thickness of a cylindrical furnace or tube under external pressure, either seamless or with longitudinal butt joints, shall be determined by the following procedure.

(a) cylinder having D_o/t values equal to or greater than 10

Step 1: Assume a value of t and determine the ratios L/D_o and D_o/t .

Step 2: Enter Fig. G of Section II, Part D, at the value of L/D_o determined in Step 1. For values of L/D_o greater than 50, enter the chart at a value of $L/D_o = 50$. For values of L/D_o less than 0.05, enter the chart at a value of $L/D_o = 0.05$.

Step 3: Move horizontally to the line for the value of D_o/t determined in Step 1. Interpolation may be made for intermediate values of D_o/t . From this point of intersection, move vertically downward to determine the value of Factor A.

Step 4: Using the value of A calculated in Step 3, enter the applicable material chart in Section II, Part D, for the material under consideration. Move vertically to an intersection with the material/temperature line for the design temperature. Interpolation may be made between lines for intermediate temperatures. In cases where the A value falls to the right of the end of the material/temperature line, assume an intersection with the horizontal projection of the upper end of the material/temperature line. For values of A falling to the left of the material/temperature line, see Step 7.

Step 5: From the intersection obtained in Step 4, move horizontally to the right and read the value of Factor B.

Step 6: Using the value of B, calculate the value of the maximum allowable external pressure, P_a , using the following formula:

$$P_a = \frac{4B}{3(D_o/t)}$$

Step 7: For values of A falling to the left of the applicable material/temperature line, the value of P_a shall be calculated using the following formula:

$$P_a = \frac{2AE}{3(D_o/t)}$$

Step 8: Compare the calculated value of P_a obtained in Step 6 or 7 with P . If P_a is smaller than P , select a larger value for t and repeat the design procedure until a value of P_a is obtained that is equal to or greater than P .

(b) cylinders having D_o/t values of less than 10

Step 1: Using the same procedure as given in (a) above, obtain the value of B. For values of D_o/t less

than 4, the value of A shall be calculated using the following formula:

$$A = \frac{1.1}{(D_o/t)^2}$$

For values of A greater than 0.10, use a value of 0.10.

Step 2: Using the value of B obtained in Step 1, calculate a value of P_{a1} using the following formula:

$$P_{a1} = \left[\frac{2.167}{D_o/t} - 0.0833 \right] B$$

Step 3: Calculate a value of P_{a2} using the following formula:

$$P_{a2} = \frac{2S_B}{D_o/t} \left[1 - \frac{1}{D_o/t} \right]$$

where S_B is the lesser of 2 times the maximum allowable

stress values at design metal temperature from Tables 1A and 1B of Section II, Part D; or, 1.8 times the yield strength of the material at Design Metal Temperature from Table Y-1 of Section II, Part D.

Step 4: The smaller of the values of P_{a1} calculated in Step 2, or P_{a2} calculated in Step 3 shall be used for the maximum allowable external pressure P_a . If P_a is smaller than P , select a larger value for t and repeat the design procedure until a value for P_a is obtained that is equal to or greater than P .

PFT-51.1.3 The design pressure or maximum allowable working pressure shall not be less than the maximum expected difference in operating pressure that may exist between the outside and the inside of the furnace or tube at any time.

PFT-51.1.4 When necessary, furnaces shall be provided with stiffeners or other additional means of support to prevent overstress or large distortions under the external loadings listed in PG-22 other than pressure and temperature.

PART PFH

OPTIONAL REQUIREMENTS FOR

FEEDWATER HEATER

(WHEN LOCATED WITHIN SCOPE OF

SECTION I RULES)

PFH-1

A feedwater heater is a heat exchanger in which feedwater to be supplied to a boiler is heated by steam or water extracted from the boiler or the prime mover. When such a feedwater heater is located within the limit of Section I piping, as defined by PG-58.3, it falls within the scope of Section I rules. With this arrangement, the feedwater heater may be constructed in compliance with Section VIII, Division 1, subject to the following conditions.

PFH-1.1 The feedwater heater shall conform with Section VIII, Division 1 rules for unfired steam boilers [UW-2(c)].

PFH-1.2 The maximum allowable working pressure of the primary (feedwater) side of the heater shall be not less than the design pressure requirements of ASME B31.1, para. 122.1.3.

PFH-1.3 The design temperature of the tubes shall be not less than the saturated steam temperature corresponding to the maximum allowable working pressure of the shell. If the steam entering the shell side of the feedwater heater is superheated, the design temperature of the tubes in the desuperheating zone shall be not less than the saturation temperature corresponding to maximum allowable shell side working pressure plus 35°F (19°C).

PFH-1.4 The feedwater heater shall be stamped with the ASME Code “U” symbol and be documented with the ASME U-1 Data Form.

PFH-1.5 A nameplate per UG-119 shall be furnished and shall show the additional information “and Part PFH of Section I.”

PFH-1.6 The Master Data Report for the completed boiler unit (using Manufacturers’ Data Report Form P-2, P-3, P3A, or P-5, as applicable) shall indicate “Feedwater heater constructed to Section VIII, Division 1, as permitted by Part PFH.”

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PART PMB

REQUIREMENTS

FOR MINIATURE BOILERS

GENERAL

PMB-1 GENERAL

The rules in Part PMB are applicable to miniature boilers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the special requirements in the applicable Parts of this Section that apply to the method of fabrication used.

PMB-2 SCOPE

This paragraph contains special rules of construction for miniature boilers only. The classification miniature applies to boilers that do not exceed the following limits:

- 16 in. (406 mm) inside diameter of shell
- 20 sq ft (1.9 m²) heating surface (not applicable to electric boilers)
- 5 cu ft (0.14 m³) gross volume,¹ exclusive of casing and insulation
- 100 psig (690 kPa) maximum allowable working pressure

Where any of the above limits are exceeded, the rules for power boilers shall apply. If the boiler meets the miniature classification, the rules in this paragraph shall supplement the rules for power boilers and take precedence over them when there is conflict.

MATERIALS

PMB-5 GENERAL

PMB-5.1 Materials used in the construction of pressure parts for miniature boilers shall conform to one

¹ This gross volume is intended to include such gas passages as are integral with the assembled pressure parts and a definition is: the volume of a rectangular or cylindrical enclosure into which all the pressure parts of the boiler in their final assembled positions could be fitted. Projecting nozzles or fittings need not be considered in the volume.

of the specifications in Section II and shall be limited to those for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, unless specifically permitted in the other applicable Parts of this Section.

PMB-5.2 Steel plates subject to pressure in any part of a miniature boiler shall be of pressure vessel quality. The plates for shells or heads shall be not less than $\frac{1}{4}$ in. (6 mm) in thickness, except that seamless shells shall be not less than $\frac{3}{16}$ in. (4.8 mm) in thickness. Heads used as tubesheets, with tubes rolled in, shall be at least $\frac{5}{16}$ in. (8 mm) in thickness.

PMB-5.3 Steam boiler parts of not over 600 cu in. (9.83 m³) in volume may be cast from copper alloy complying with requirements of SB-61 or SB-62 of wall thickness not less than $\frac{1}{4}$ in. (6 mm). Such steam boiler parts shall be equipped with at least one brass washout plug of not less than $\frac{1}{2}$ in. (13 mm) and shall be tested to a hydrostatic pressure of 600 psi (4 140 kPa).

PMB-5.4 Heads or parts of miniature boilers, when not exposed to the direct action of the fire, may be made of cast iron or malleable iron provided it complies with a specification permitted in this Section.

PMB-5.5 Due to the small size of parts of miniature boilers, the requirements of Identification, PG-77.1, need not be met, provided the Manufacturer certifies on the Data Report accompanying the boiler that the material is in accordance with the requirements of this Section. Provisions shall be made by the Manufacturer whereby he shall be able to supply complete information regarding the material and details of construction of any boiler built under the provisions of this Code.

DESIGN

PMB-8 GENERAL

The rules in the following paragraphs apply specifically to the design of miniature boilers and parts

thereof and shall be used in conjunction with the general requirements for design in Part PG as well as with the specific requirements for design in the applicable Parts of this Section which apply to the method of fabrication used.

PMB-9 WELDING

Miniature boilers may be constructed by fusion welding in accordance with all the requirements of this Section except that postweld heat treatment, radiography of the welded joints, and nondestructive examinations described in PG-93.1 are not required.

PMB-10 WASHOUT OPENINGS

PMB-10.1 Every miniature boiler exceeding 12 in. (305 mm) internal diameter or having more than 10 sq ft (0.9 m²) of heating surface shall be fitted with not less than three brass washout plugs of 1 in. (25 mm), which shall be screwed into openings in the shell near the bottom. In miniature boilers of the closed-system type heated by removable internal electric heating elements, the openings for these elements when suitable for cleaning purposes may be substituted for washout openings. Boilers not exceeding 12 in. (305 mm) internal diameter and having less than 10 sq ft (0.9 m²) of heating surface need have not more than two 1 in. openings for cleanouts, one of which may be used for the attachment of the blowoff valve; these openings shall be opposite to each other where possible. All threaded openings in the boiler shall be provided with a welded reinforcement, if necessary, to give four full threads therein.

PMB-10.2 Electric boilers of a design employing a removable top cover flange for inspection and cleaning need not be fitted with washout openings.

PMB-11 FEEDWATER SUPPLY

Every miniature boiler shall be provided with at least one feed pump or other feeding device, except where it is connected to a water main carrying sufficient pressure to feed the boiler or where it is operated with no extraction of steam (closed system). In the latter case, in lieu of a feeding device, a suitable connection or opening shall be provided to fill the boiler when cold. Such connection shall be not less than NPS ½ (DN 15) for iron or steel pipe and NPS ¼ for brass or copper pipe.

The feed pipe shall be provided with a check valve and a stop valve of a size not less than that of the pipe. The feedwater may be delivered through the blowoff opening if desired.

PMB-12 BLOWOFF

Each miniature boiler shall be equipped with a blow-off connection, not less than NPS ½ (DN 15), located to drain from the lowest water space practicable. The blowoff shall be equipped with a valve or cock not less than NPS ½ (DN 15).

PMB-13 WATER GAGES

Each miniature boiler for operation with a definite water level shall be equipped with a water gage glass for determining the water level. The lowest permissible water level of vertical boilers shall be at a point one-third of the height of the shell above the bottom head or tubesheet. Where the boiler is equipped with internal furnace, the water level shall be not less than one-third of the length of the tubes above the top of the furnace tubesheet. In the case of small boilers operated in a closed system where there is insufficient space for the usual water gage glass, water level indicators of the glass bull's-eye type may be used.

Miniature boilers shall have the lowest visible part of the water gage located at least 1 in. (25 mm) above the lowest permissible water level specified by the Manufacturer.

PMB-14 FIXTURES AND FITTINGS

All valves, pipe fittings, and appliances connected to a miniature boiler shall be equal at least to the requirements of Class 125 or Class 150 of the appropriate ASME Standard listed in PG-42.

PMB-15 SAFETY VALVES

Each miniature boiler shall be equipped with a sealed spring loaded safety valve of not less than NPS ½ (DN 15).

The minimum relieving capacity of the safety valve shall be determined in accordance with PG-70. In addition to these requirements, the safety valve shall have sufficient capacity to discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the maximum allowable working pressure.

All other provisions for safety valves in this Section shall be complied with.

PMB-16 STEAM STOP VALVES

Each steam line from a miniature boiler shall be provided with a stop valve located as close to the boiler shell or drum as is practicable, except when the boiler and steam receiver are operated as a closed system.

PMB-17 AUTOMATIC DEVICES

All miniature boilers, except as provided by PEB-13, operated with gas, electricity, oil, or mechanical firing, shall be provided with an automatic low-water fuel cutoff.

PMB-21 INSPECTION

In addition to the inspections required elsewhere in this Section, each miniature boiler shall be inspected while being tested at a hydrostatic pressure equal to three times the maximum allowable working pressure.

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PART PEB

REQUIREMENTS FOR ELECTRIC BOILERS

GENERAL

PEB-1 GENERAL

The rules in Part PEB are applicable to electric boilers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the special requirements in the applicable Parts of this Section that apply to the method of fabrication used.

PEB-2 SCOPE

PEB-2.1 This Part contains special rules for construction of electric boilers both of the electrode and immersion resistance element type. This Part does not include electric boilers where the heat is applied to the boiler pressure vessel externally by electric resistance heating elements, induction coils, or other electrical means. These types of electric boilers shall be constructed in accordance with other applicable Parts of this Section.

PEB-2.2 Electric boilers shall be marked with the “S” or “M” symbol (except when the boiler pressure vessel is constructed under the provisions of PEB-3) by the Manufacturer of the boiler pressure vessel. When the trim, fixtures, and fittings such as valves, threaded piping, and appurtenances are connected to the electric boiler by a Manufacturer not authorized to apply the “S” or “M” stamps, the boiler assembler shall apply an “E” stamp to the completed assembly. “E” stamp holders are limited to the use of assembly methods that do not require welding or brazing.

PEB-2.3 An electrode type boiler is defined as an electric boiler in which heat is generated by the passage of an electric current using water as the conductor.

PEB-2.4 An immersion resistance element type boiler is defined as an electric boiler in which heat is generated by the passage of an electric current through a resistance heating element immersed in water.

PEB-3 OPTIONAL REQUIREMENTS FOR THE BOILER PRESSURE VESSEL

The boiler pressure vessel may be constructed in compliance with the ASME Pressure Vessel Code Section VIII, Division 1, rules for unfired steam boilers [UW-2(c)] subject to the following conditions:

PEB-3.1 The Manufacturer who certifies and stamps the completed boiler shall specify to the “U” stamp holder all additional requirements of Part PEB, which are not requirements of Section VIII, Division 1, and shall ensure that these requirements are satisfied.

PEB-3.2 These additional requirements are:

PEB-3.2.1 The materials of construction shall comply with the requirements of PEB-5.1 and PEB-5.3.

PEB-3.2.2 Inspection openings shall comply with the requirements of PEB-10.

PEB-3.3 The boiler pressure vessel shall be stamped with the ASME Code “U” symbol and be documented with the ASME U-1 or U-1A Data Report.

PEB-3.4 The master Data Report P-2A for the Electric Boiler shall indicate “Boiler pressure vessel constructed to Section VIII, Division 1 as permitted by Part PEB.”

MATERIALS

PEB-5 GENERAL

PEB-5.1 Materials used in the construction of pressure parts for electric boilers shall conform to one of the specifications in Section II and shall be limited to those permitted by PG-6, PG-7, PG-8, and PG-9 for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, unless specifically permitted in other applicable parts of this Section.

PEB-5.2 The plates or heads shall not be less than $\frac{3}{16}$ in. (4.8 mm) in thickness.

PEB-5.3 Electric boilers of the immersion element type may be fabricated of austenitic stainless steel type 304, 304L, 316 and 316L, of any material specification listed in PG-6 and PG-9, under the following conditions:

(a) The vessel shall not exceed the diameter, volume, or pressure limits of PMB-2 for miniature boilers.

(b) A precautionary statement that the boiler shall be operated on deionized water only, having a minimum specific resistivity of 1 megohm-cm, shall be clearly marked on the boiler in a visible location.

DESIGN

PEB-8 GENERAL

PEB-8.1 The rules in the following paragraphs apply specifically to the design of electric boilers and parts thereof and shall be used in conjunction with the general requirements for design in Part PG, as well as with the specific requirements for design in applicable Parts of this Section that apply to the method of fabrication used.

PEB-8.2 Responsibility of design of electric boilers to be marked with the “E” symbol shall be that of the holder of the “E” stamp.

PEB-9 WELDING

PEB-9.1 Electric boilers may be constructed by fusion welding in accordance with all the requirements of this Section except that neither postweld heat treatment nor radiography of the welded joints are required when the following limitations are not exceeded:

- (a) 16 in. (406 mm) inside diameter of shell
- (b) 100 psig (690 kPa) maximum allowable working pressure

PEB-10 INSPECTION OPENINGS

PEB-10.1 Electric boilers of a design employing a removable cover which will permit access for inspection and cleaning and having an internal volume (exclusive of casing and insulation) of not more than 5 cu ft (0.14 m³) need not be fitted with washout or inspection openings.

PEB-10.2 Electric boilers of more than 5 cu ft (0.14 m³) not provided with a manhole, shall have an inspection opening or handhole located in the lower

portion of the shell or head. The inspection opening shall not be smaller than NPS 3 (DN 80). In addition, electric boilers of the resistance heating element type designed for steam service shall have an inspection opening or handhole at or near the normal waterline.

PEB-11 FEEDWATER SUPPLY

PEB-11.1 The feedwater source to electric boilers shall be capable of meeting the applicable requirements of PG-61.

PEB-11.2 Feedwater connections to an electric boiler shall not be smaller than NPS $\frac{1}{2}$ (DN 15).

PEB-12 BLOWOFF

PEB-12.1 The blowoff piping for each electric boiler pressure vessel having a normal water content not exceeding 100 gal (380 l) is required to extend through only one valve.

PEB-12.2 The minimum size of blowoff pipes and fittings shall be NPS 1 (DN 25), except that for boilers of 200 kW input or less the minimum size of pipe and fittings may be NPS $\frac{3}{4}$ (DN 20).

PEB-13 WATER GAGES

PEB-13.1 Electric boilers of the electrode type shall have at least one water gage glass. The water gage glass shall be located as to indicate the water levels both at startup and under maximum steam load conditions as established by the Manufacturer. No low-water cutoff is required for electrode type boilers.

PEB-13.2 Electric boilers of the resistance element type shall have at least one water gage glass. The lowest visible part of the water gage shall be located at least 1 in. above the lowest permissible water level specified by the Manufacturer. Each electric boiler of this type shall also be equipped with an automatic low-water cutoff on each boiler pressure vessel so located as to automatically cut off the power supply to the heating elements before the surface of the water falls below the visible part of the glass.

PEB-13.3 Tubular water glasses on electric boilers shall be equipped with protective rods or shields.

PEB-14 PRESSURE GAGES

PEB-14.1 Pressure gages shall meet the requirements of PG-60.6.

PEB-15 SAFETY VALVES

PEB-15.1 Each electric boiler shall have at least one safety valve or safety relief valve, and if it has a power input more than 1,100 kW, it shall have two or more safety valves or safety relief valves.

PEB-15.2 The minimum safety valve or safety relief valve relieving capacity for electric boilers shall be $3\frac{1}{2}$ lb/hr/kW (1.6 kg/hr/kW) input.

PEB-16 AUTOMATIC DEVICES

PEB-16.1 Electric boilers shall be provided with pressure and/or temperature controls.

PEB-17 HYDROSTATIC TEST

PEB-17.1 Each electric boiler pressure vessel shall be hydrostatically tested at completion of fabrication in accordance with PG-99 or PMB-21, as applicable.

PEB-17.2 In addition to the above, after assembly of the boiler pressure vessel and the external threaded piping, the electric boiler shall be given a final hydrostatic test at a pressure not less than the safety valve setting.

PEB-17.3 When the electric boiler is to be marked with the "E" symbol, the symbol shall be applied after completion of the hydrostatic test of PEB-17.2.

PEB-18 INSPECTION AND STAMPING OF BOILERS

PEB-18.1 Inspection of electric boilers shall be as required by PG-90.1 and PG-90.3, except that for completed electric boilers having only threaded external piping and not exceeding either 800 kW per vessel or 600 V, inspection by the Authorized Inspector after completion of assembly and trim may be omitted provided the electric boiler Manufacturer shall make an equivalent examination of the completed electric boiler in accordance with a quality control procedure meeting the requirements of PEB-18.2. Inspection of the boiler pressure vessel by the Authorized Inspector, during and after construction, shall be in accordance with PG-90.1 and PG-90.3.

PEB-18.1.1 Electric boilers having only threaded piping and exceeding the size limitations specified in PEB-18.1 shall have a final inspection by the Authorized Inspector and who shall witness the hydrostatic test called for in PEB-17.2.

PEB-18.1.2 For electric boilers having welded external trim the inspection requirements of PG-90.1 and the hydrostatic test requirements of PG-99 apply.

PEB-18.2 Each electric boiler Manufacturer shall comply with the applicable requirements of PG-104 and PG-105. The facilities and organization of electric boiler Manufacturers or assemblers applying for or renewing the "E" stamp shall be subject to a joint review by his inspection agency and the legal jurisdiction involved (see last paragraph of PG-105.4).

PEB-18.2.1 Those Manufacturers holding an "E" stamp and assembling units where the final shop inspection is not mandatory (see PEB-18.1) shall be subject to review by his Authorized Inspector's Agency on a quarterly or more frequent basis if deemed necessary by the Authorized Inspector's Agency. However, subject to written agreement between the Manufacturer and his inspection agency and the written approval of the appropriate legal authority under which the Authorized Inspector is commissioned, the frequency of this review may vary, but in no case shall it exceed the period of 6 months.

PEB-18.3 The stamping of electric boilers shall conform to the requirements of PG-106.

PEB-18.3.1 The stamping of the boiler pressure vessel shall be located as called for in PG-111.8 and need not indicate the kW input or the maximum designed steaming capacity.

PEB-18.3.2 The stamping of the complete electric boiler shall be on a separate metallic plate and shall be in accordance with PG-106.4.1. This plate shall be located on the assembly so that it is readily visible from the operating floor.

PEB-18.3.3 For those electric boilers that do not receive final inspection by the Authorized Inspector (see PEB-18.1) the stamping required by PEB-18.3.2 need not be done in the presence of the Authorized Inspector.

PEB-18.4 For boiler pressure vessels constructed under the provisions of PEB-3, the inspection and stamping requirements of Section VIII, Division 1 shall be followed.

**PEB-19 MANUFACTURERS' DATA
REPORT FOR ELECTRIC BOILERS**

PEB-19.1 This form consists of two parts. Part I is to be completed by the Manufacturer of the boiler pressure vessel who is the holder of the "S" or "M" stamp and his inspection agency. Part II is to be completed by the Manufacturer responsible for the completed electric boiler who shall be authorized to use any of the "S," "M," or "E" stamps.

PEB-19.2 When the boiler pressure vessel is constructed by a "U" stamp holder and certified on a U-1 or U-1A Data Report, Part 1 shall be completed by the "S," "M," or "E" stamp holder to the extent indicated in Guide A-351.1.

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PART PVG

REQUIREMENTS FOR ORGANIC FLUID

VAPORIZERS

GENERAL

PVG-1 GENERAL

The rules in Part PVG are applicable to organic fluid vaporizers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the special requirements in the applicable Parts of this Section that apply to the method of fabrication used.

MATERIALS

PVG-5 GENERAL

PVG-5.1 Materials used in the construction of pressure parts for organic fluid vaporizers shall conform to one of the specifications in Section II and shall be limited to those for which allowable stress values are given in Tables 1A and 1B of Section II, Part D. Safety valve materials shall conform to PG-73.2.3.

PVG-5.2 The requirements for materials given in Part PG shall apply in all respects to organic fluid vaporizers.

DESIGN

PVG-8 GENERAL

The rules in the following paragraphs apply specifically to the design of organic fluid vaporizers and parts thereof and shall be used in conjunction with the general requirements for design in Part PG as well as with the specific requirements for design in the applicable Parts of this Section that apply to the method of fabrication used.

PVG-9 GENERAL REQUIREMENTS

The Manufacturer shall be responsible for providing in the design the limited heat absorption rates, proper

furnace proportions, etc., which will permit satisfactory and safe operation of the vaporizers under all conditions of operation.

PVG-10 GAGE GLASSES

Gage glasses shall be of the flat glass type with forged steel frames. Gage cocks shall not be used.

PVG-11 DRAIN VALVES

Suitable drain valves of the globe or angle type may be used in lieu of the blowoff valve required in ASME B31.1.

PVG-12 SAFETY VALVES

PVG-12.1 Safety valves shall be of a totally enclosed type so designed that vapors escaping beyond the valve seat shall not discharge into the atmosphere, except through an escape pipe that will carry such vapors to a safe point of discharge outside of the building. A suitable condenser that will condense all the vapors discharged from the safety valve may be used in lieu of piping the vapors to the atmosphere. The safety valve shall not have a lifting lever. The vaporizer shall be designed in accordance with the rules in this Code for a working pressure of at least 40 psi (256 kPa) above the operating pressure at which it will be used. Valve body drains are not mandatory.

PVG-12.2 Safety valves shall be disconnected from the vaporizer at least once yearly, when they shall be inspected, repaired if necessary, tested, and then replaced on the vaporizer.

PVG-12.3 In order to minimize the loss by leakage of material through the safety valve, a rupture disk may be installed between the safety valve and the vaporizer provided the following requirements are met.

PVG-12.3.1 The cross-sectional area of the connection to a vaporizer shall be not less than the required relief area of the rupture disk.

PVG-12.3.2 Every rupture disk shall have a specified bursting pressure at a specified temperature, shall be marked with a lot number, and shall be guaranteed by its manufacturer to burst within 5% (plus or minus) of its specified bursting pressure.

PVG-12.3.3 The specified bursting pressure at the coincident specified temperature shall be determined by bursting two or more specimens from a lot of the same material and of the same size as those to be used. The tests shall be made in a holder of the same form and pressure area dimensions as that with which the disk is to be used.

PVG-12.3.4 A rupture disk may be installed between a safety valve and the vaporizer provided:

PVG-12.3.4.1 The maximum pressure of the range for which the disk is designed to rupture does not exceed the opening pressure for which the safety valve is set or the maximum allowable working pressure of the vessel.

PVG-12.3.4.2 The opening provided through the rupture disk, after breakage, is sufficient to permit a flow equal to the capacity of the attached valve and there is no chance of interference with the proper functioning of the valve; but in no case shall this area be less than the inlet area of the valve.

PVG-12.3.4.3 The space between a rupture disk and the valve should be provided with a pressure gage, try cock, free vent, or a suitable telltale indicator. This arrangement permits the detection of disk rupture or leakage.¹

PVG-12.4 Safety valve discharge capacity shall be determined from the formula:

Customary Units

$$W = CKAP \sqrt{M/T}$$

SI Units

$$W = 0.051CKAP \sqrt{M/T}$$

¹ Users are warned that a rupture disk will not burst at its designed pressure if back pressure builds up in the space between the disk and the safety valve, which will occur should leakage develop in the rupture disk due to corrosion or other cause.

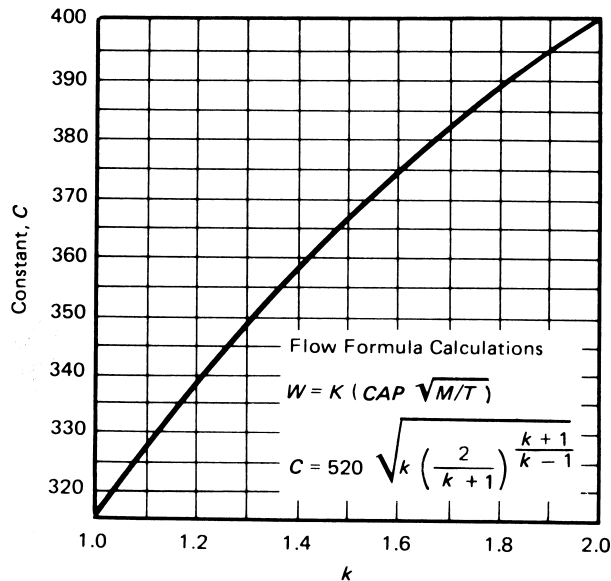


FIG. PVG-12 CONSTANT C FOR VAPOR RELATED TO RATIO OF SPECIFIC HEATS ($k = c_p/c_v$)

where

W = flow of vapor, lb/hr (kg/hr)

C = constant for vapor that is a function of the ratio of Specific Heats $k = c_p/c_v$ (see Fig. PVG-12)

Note: Where k is not known, $k = 1.001$.

K = coefficient of discharge for the design

A = discharge area of safety valve, sq in. (mm²)

P = (set pressure $\times 1.03$) + Atmosphere Pressure, psia (kPa.abs)

M = molecular weight

T = absolute temperature at inlet, °F + 460 (°C + 273)

PVG-12.5 Safety valves for organic fluid vaporizers shall be tested and certified under PG-69, and they shall be stamped with the rated relieving capacity in pounds per hour at coincident temperature as determined in PVG-12.4. The fluid identification shall be stamped on the nameplate.

PVG-12.6 The required minimum safety valve relieving capacity shall be determined from the formula:

$$W = \frac{C \times H \times 0.75}{h}$$

where

h = latent heat of heat transfer fluid at relieving pressure, Btu/lb (J/kg)

W = weight of organic fluid vapor generated per hour, lb (kg)

C = maximum total weight or volume of fuel burned
per hour, lb (kg) or cu ft (m^3)

H = heat of combustion of fuel, Btu/lb (J/kg) or
Btu/cu ft (J/m^3) (see A-17)

The sum of the safety valve capacities marked on the
valves shall be equal to or greater than W .



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APPENDIX I — MANDATORY PREPARATION OF TECHNICAL INQUIRIES TO THE BOILER AND PRESSURE VESSEL COMMITTEE

I-100 INTRODUCTION

The ASME Boiler and Pressure Vessel Committee meets regularly to consider written requests for interpretations and revisions to the Code rules, and to develop new rules as dictated by technological development. The Committee's activities in this regard are limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. As a matter of published policy, ASME does not approve, certify, or endorse any item, construction, proprietary device, or activity, and, accordingly, inquiries requiring such consideration will be returned. Moreover, ASME does not act as a consultant on specific engineering problems or on the general application or understanding of the Code rules. If, based on the inquiry information submitted, it is the opinion of the Committee that the inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

All inquiries that do not provide the information needed for the Committee's full understanding will be returned.

I-200 INQUIRY FORMAT

Inquiries shall be limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. Inquiries shall be submitted in the following format.

(a) *Scope.* Involve a single rule or closely related rules. An inquiry letter concerning unrelated subjects will be returned.

(b) *Background.* State the purpose of the inquiry, which would be either to obtain an interpretation of Code rules, or to propose consideration of a revision to the present rules. Provide concisely the information needed for the Committee's understanding of the inquiry, being sure to include reference to the applicable Code Section, Division, Edition, Addenda, paragraphs, figures, and tables. If sketches are provided, they shall be limited to the scope of the inquiry.

(c) *Inquiry Structure.* Prepare statements in a condensed and precise question format, omitting superfluous background information, and, where appropriate, composed in such a way that "yes" or "no" (perhaps with provisos) would be an acceptable reply. This inquiry statement should be technically and editorially correct.

(d) *Proposed Reply.* State what it is believed that the Code requires. If in the inquirer's opinion a revision to the Code is needed, recommended wording shall be provided.

I-300 SUBMITTAL

Inquiries shall preferably be submitted in typewritten form; however, legible handwritten inquiries will also be considered. They shall include the name and mailing address of the inquirer, and be mailed to the following address:

Secretary
ASME Boiler and Pressure Vessel Committee
Three Park Avenue
New York, N.Y. 10016-5990

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APPENDIX A

EXPLANATION OF THE CODE

CONTAINING MATTER NOT MANDATORY UNLESS SPECIFICALLY REFERRED TO IN THE RULES OF THE CODE

BRACED AND STAYED SURFACES

A-8

The allowable loads based on the net cross-sectional areas of staybolts with V-threads are computed from the following formulas. The use of Whitworth threads with other pitches is permissible.

The formula for the diameter of a staybolt at the bottom of a V-thread is:

$$D - (P \times 1.732) = d$$

where

D = diameter of staybolt over the threads, in.

P = pitch of threads, in.

= 1/number of threads/in.

d = diameter of staybolt at bottom of threads, in.

1.732 = a constant

When ANSI Standard threads are used, the formula becomes

$$D - (P \times 1.732 \times 0.75) = d$$

METHOD OF CHECKING SAFETY- VALVE CAPACITY BY MEASURING MAXIMUM AMOUNT OF FUEL THAT CAN BE BURNED

A-12

The maximum quantity of fuel C that can be burned per hour at the time of maximum forcing is determined

by a test. The maximum number of heat units per hour, or CH , is then determined, using the values of H given in A-17. The weight of steam generated per hour is found by the formula:

Customary Units

$$W = \frac{C \times H \times 0.75}{1,100}$$

SI Units

$$W = \frac{C \times H \times 0.75}{2,558}$$

where

W = weight of steam generated/hr, lb (kg/hr)

C = total weight or volume of fuel burned/hr (kN/hr) at time of maximum forcing, lb (kg) or cu ft/kg (m³)

H = heat of combustion of fuel, Btu/lb or Btu/cu ft (see A-17)

The sum of the safety valve capacities marked on the valves shall be equal to or greater than W .

A-13 Example 1

A boiler at the time of maximum forcing uses 2,150 lb/hr of Illinois coal with a heating value of 12,100 Btu/lb. Boiler pressure is 225 psi gage.

Fig. A-8

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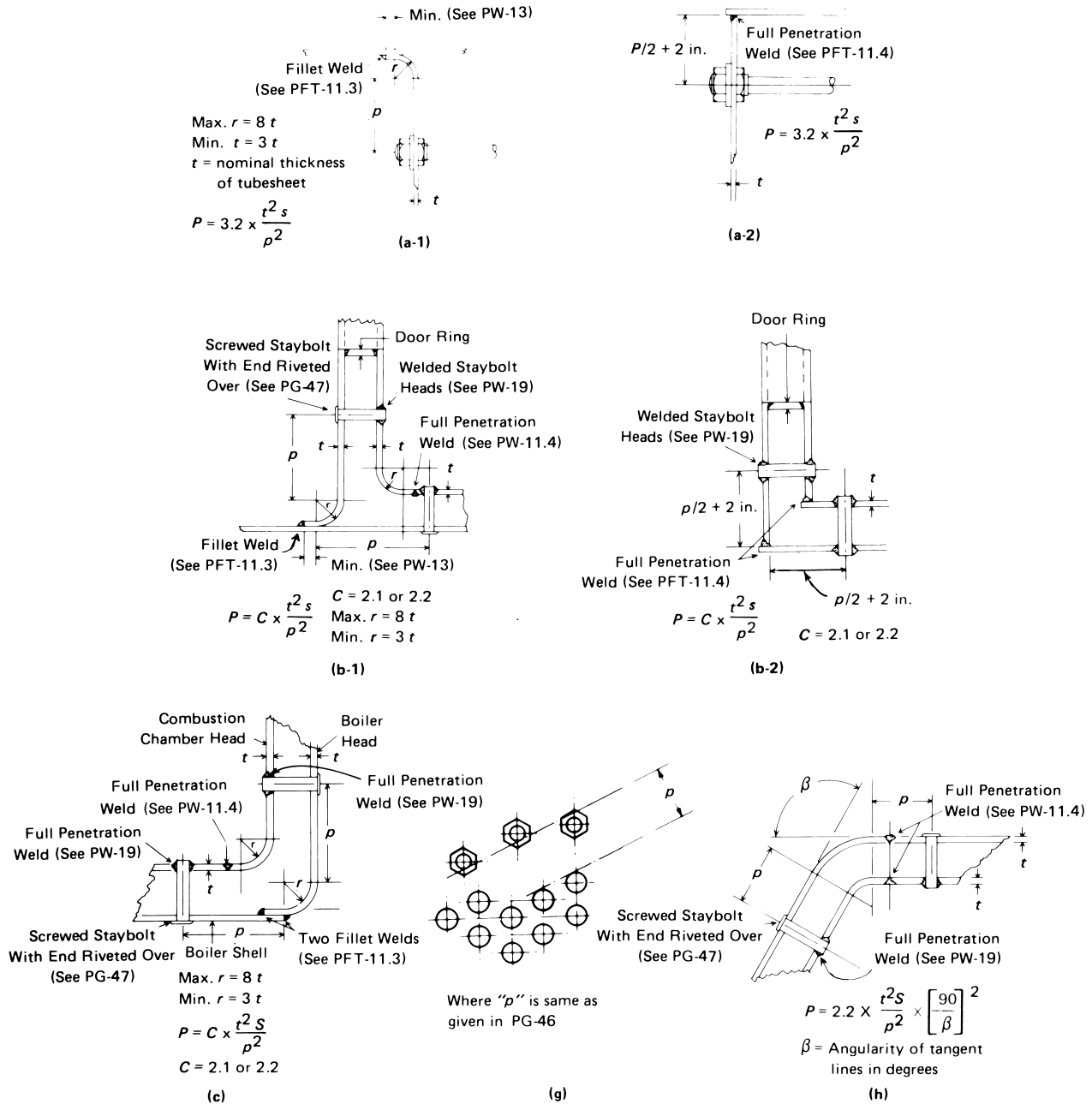


FIG. A-8 DETAIL SKETCHES SHOWING APPLICATION OF PG-48 AND PFT-27 TO THE STAYING OF BOILERS

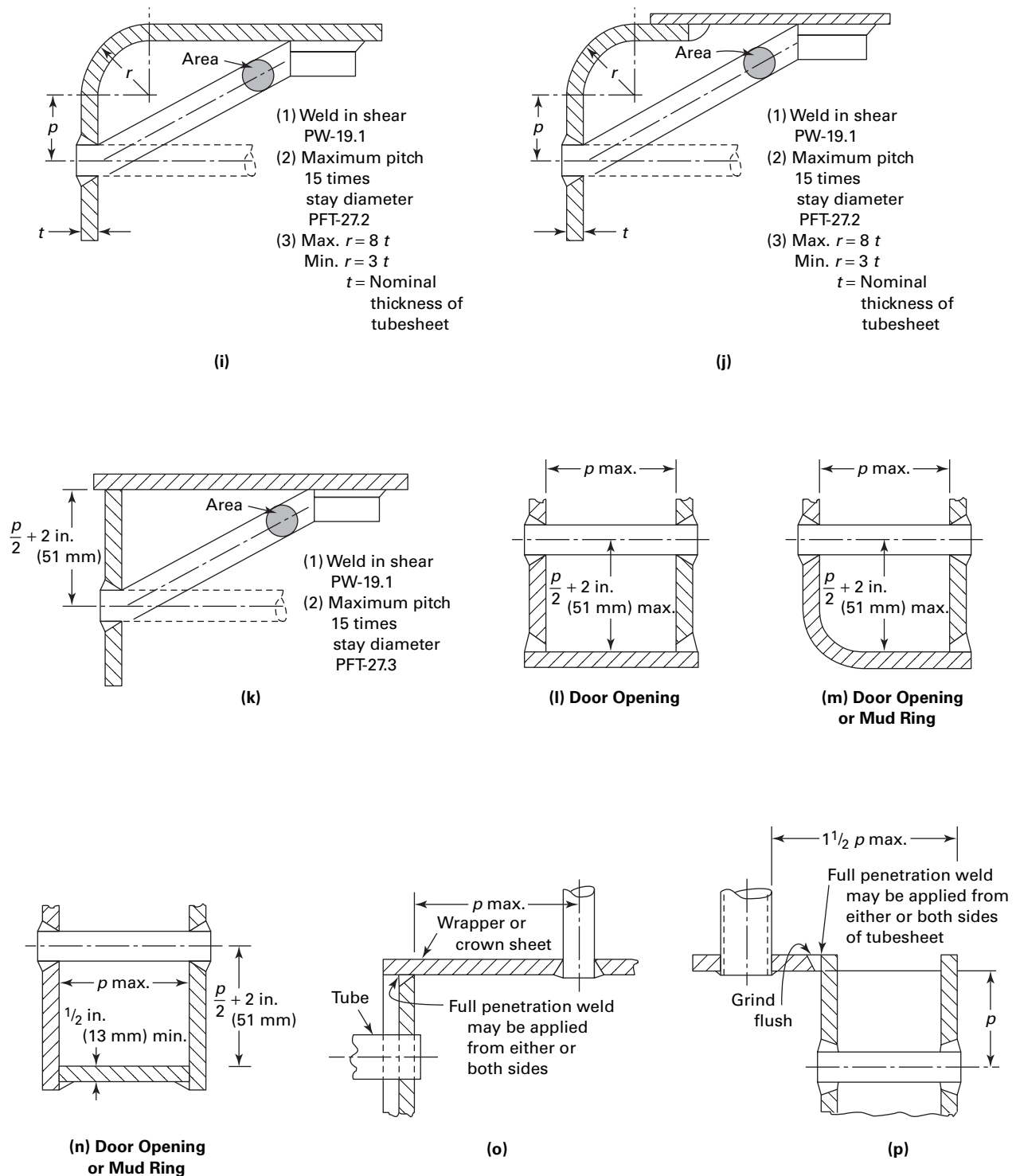
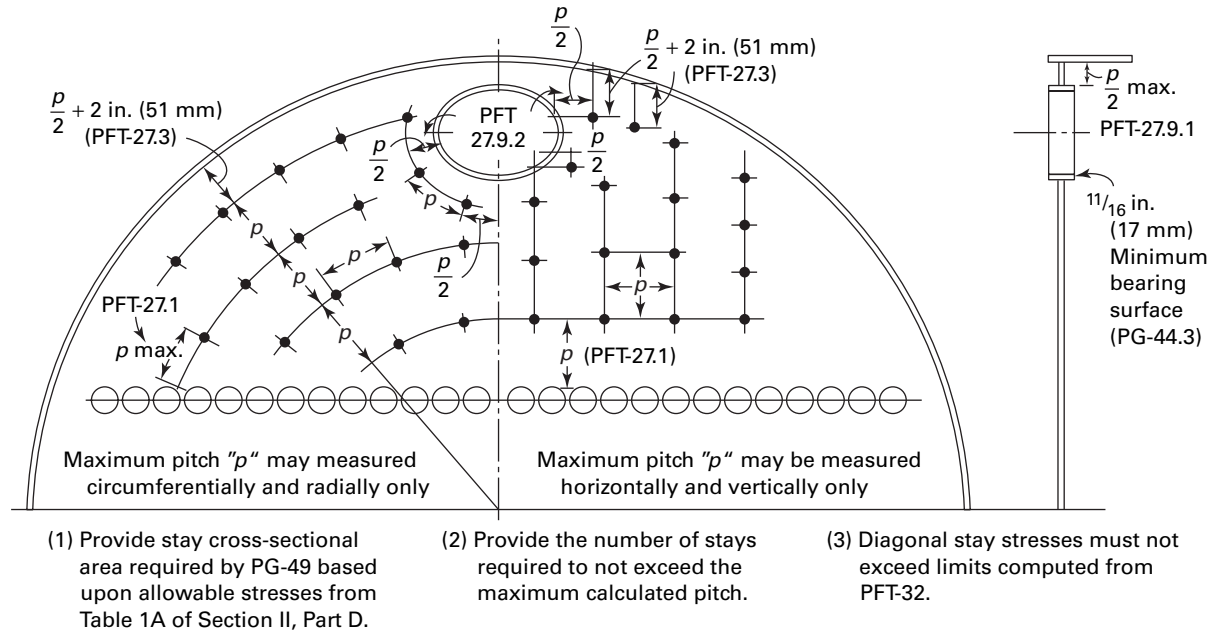


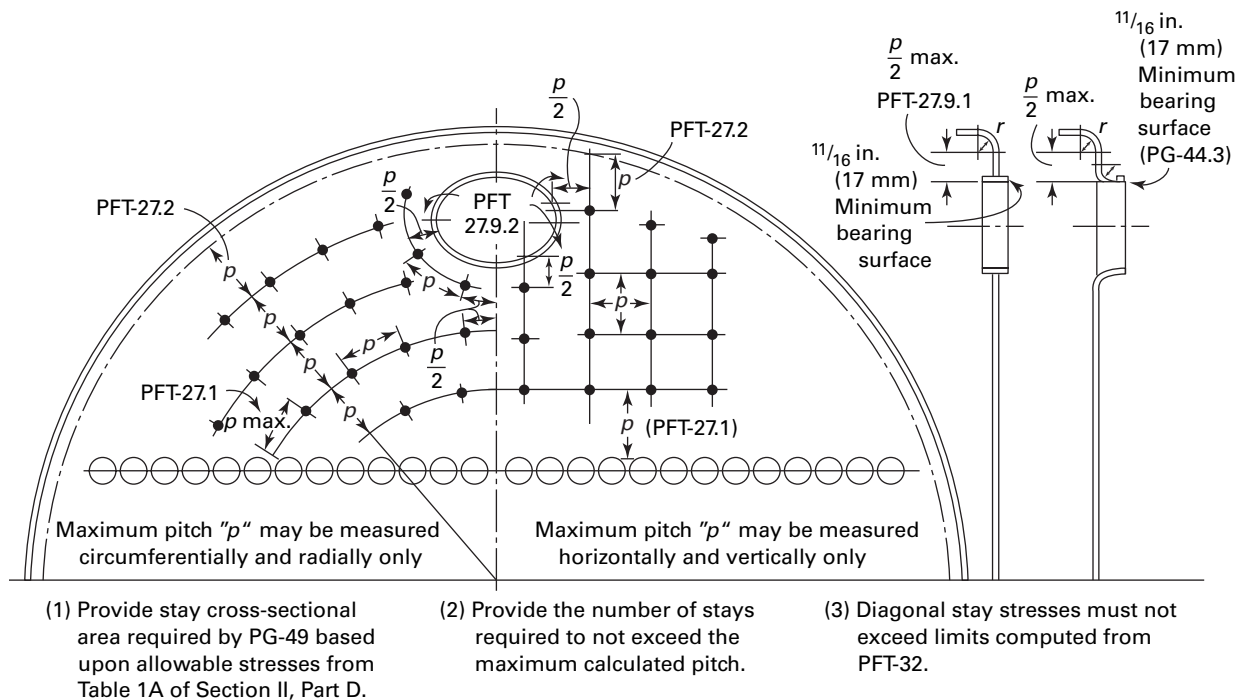
FIG. A-8 DETAIL SKETCHES SHOWING APPLICATION OF PG-48 AND PFT-27 TO THE STAYING OF BOILERS (CONT'D)

Fig. A-8

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FIG. A-8 DETAIL SKETCHES SHOWING APPLICATION OF PG-48 AND PFT-27 TO THE STAYING OF BOILERS (CONT'D)

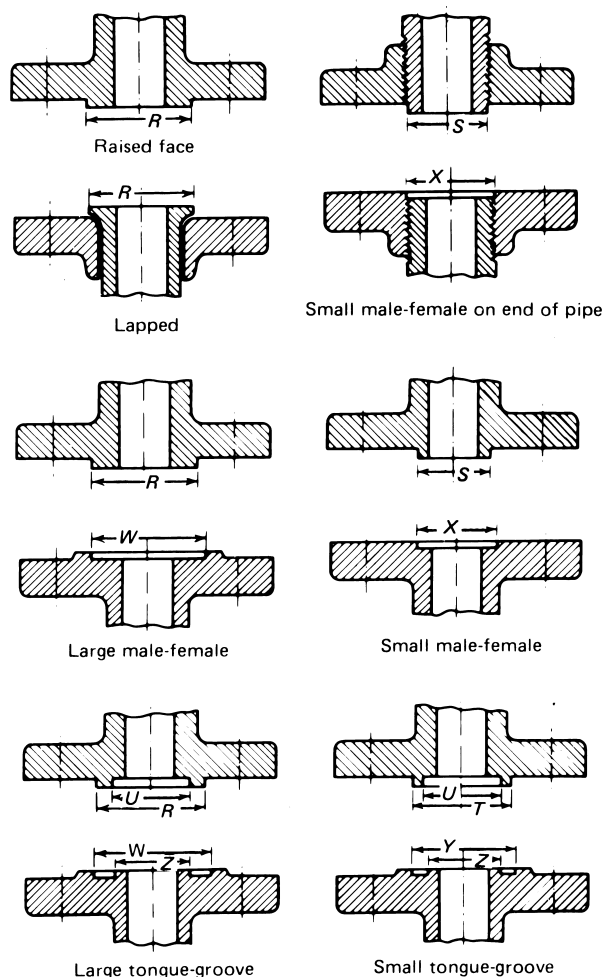


FIG. A-9 TYPICAL FACINGS

$$C \times H = 2,150 \times 12,100 = 26,015,000$$

$$W = \frac{C \times H \times 0.75}{1,100} = 17,740$$

A-14 Example 2

Wood shavings of heat of combustion of 6,400 Btu/lb are burned under a boiler at the maximum rate of 2,000 lb/hr. Boiler pressure is 100 psi gage.

$$C \times H = 2,000 \times 6,400 = 12,800,000$$

$$W = \frac{C \times H \times 0.75}{1,100} = 8,730$$

A-15 Example 3

An oil-fired boiler at maximum forcing uses 1,000 lb/hr of crude oil (Texas). Boiler pressure is 275 psi gage.

$$C \times H = 1,000 \times 18,500 = 18,500,000$$

$$W = \frac{C \times H \times 0.75}{1,100} = 12,620$$

A-16 Example 4

A boiler fired with natural gas consumes 3,000 cu ft/hr. The working pressure is 150 psi gage.

$$C \times H = 3,000 \times 960 = 2,880,000$$

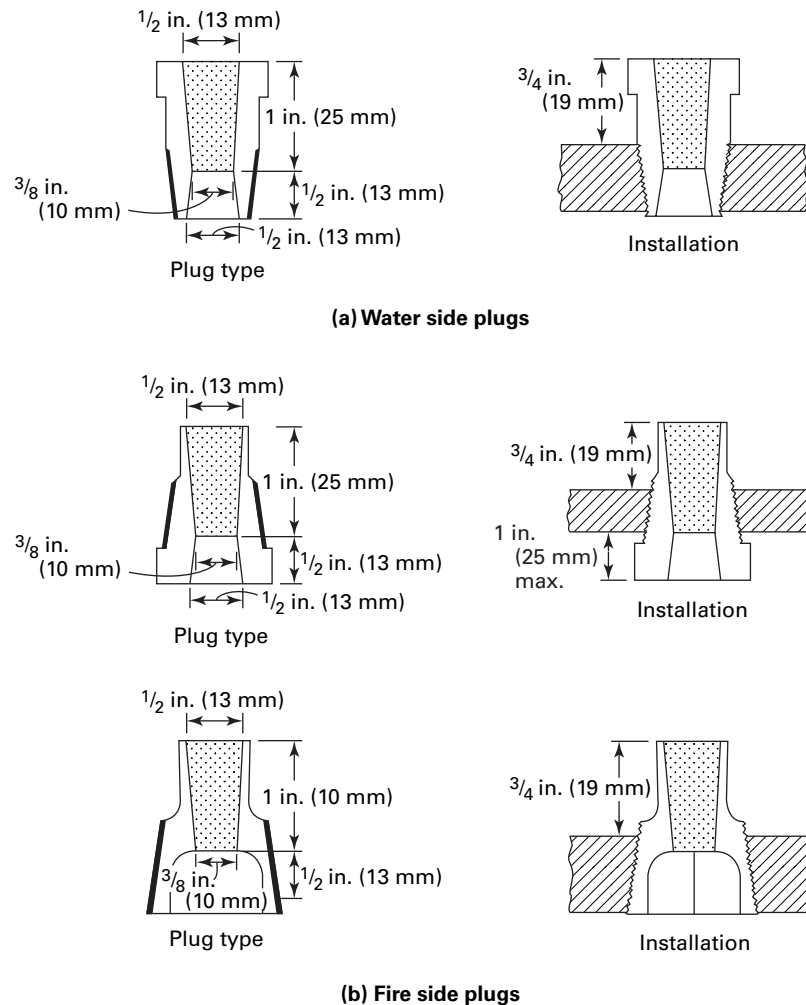
$$W = \frac{C \times H \times 0.75}{1,100} = 1,960$$

A-17

For the purpose of checking the safety valve capacity as described in A-12, the following values of heats of combustion of various fuels may be used:

	$H = \text{Btu/lb}$	(kJ/kg)
Semibituminous coal	14,500	34 000
Anthracite	13,700	32 000
Screenings	12,500	29 000
Coke	13,500	31 000
Wood, hard or soft, kiln dried	7,700	18 000
Wood, hard or soft, air dried	6,200	14 000
Wood shavings	6,400	14 400
Peat, air dried, 25% moisture	7,500	17 000
Lignite	10,000	23 300
Kerosene	20,000	46 500
Petroleum, crude oil, Pennsylvania	20,700	48 000
Petroleum, crude oil, Texas	18,500	43 000

	$H = \text{Btu/cu ft}$	(kJ/m^3)
Natural gas	960	35 700
Blast-furnace gas	100	3 700
Producer gas	150	5 600
Water gas, uncarbureted	290	11 000



GENERAL NOTE: All dimensions minimum unless otherwise specified

FIG. A-10 TYPICAL FORMS OF FUSIBLE PLUGS

AUTOMATIC WATER GAGES

A-18

Automatic shutoff valves on water gages, if permitted to be used, shall conform to the following requirements.

A-18.1 Check valves in upper and lower fittings shall be of solid noncorrosive metal ball type to avoid need for guides.

A-18.2 Ball check valves in upper and lower fittings must open by gravity and the lower ball check valve must rise vertically to its seat.

A-18.3 The check balls must not be smaller than $\frac{1}{2}$ in. (13 mm) in diameter, and the diameter of the circle

of contact with the seat must not be greater than two-thirds of the diameter of the check ball. The space around each ball must be not less than $\frac{1}{8}$ in. (3.2 mm), and the travel movement from the normal resting place to the seat must be not less than $\frac{1}{4}$ in. (6 mm).

A-18.4 The ball seat in the upper fitting must be a flat seat with either a square or hexagonal opening, or otherwise arranged so that the steam passage can never be completely closed by this valve.

A-18.5 The shutoff valve in the upper fitting must have a projection that holds the ball at least $\frac{1}{4}$ in. (6 mm) away from its seat when the shutoff valve is closed.

A-18.6 The balls must be accessible for inspection. Means must be provided for removal and inspection of the lower ball check valve while the boiler is under steam pressure.

These restrictions do not apply to closing the valves by external methods.

FUSIBLE PLUGS

A-19

A-19.1 Fire-actuated fusible plugs, if used, except as provided in A-20.9, shall be filled with tin of the following composition, having a melting point between 445°F and 450°F (229°C and 232°C):

Pure tin, min.....	99.3%
Copper, max	00.5%
Lead, max	00.1%
Total impurities.....	00.7%

A-19.2 The fusible metal shall extend from the water end of the plug to the point of least diameter of the hole and shall be carefully alloyed to the casing. A test shall be made to determine that the fusible metal is not loose in the plug.

A-19.3 Fusible plugs shall be renewed at least once each year. Casings that have been used shall not be refilled.

A-19.4 Fusible plugs filled with tin as specified in A-19.1 shall not be used for pressures and temperatures that will cause the plug to fail while it is submerged in the boiler water.

The fusible metal may be partly replaced by a bronze plug loosely fitted to the hole and of such size that it will pass freely through the hole on the fire side, from which side it must be inserted into the casing. Such plug shall be properly alloyed to the casing with the same fusible metal as required by A-19.1.

A-20

A-20.1 Water side plugs are fusible plugs that are inserted from the water side of the plate, flue, or tube to which they are attached. Fire side plugs are fusible plugs inserted from the fire side of the plate, flue, or tube to which they are attached.

A-20.2 The casing of the fusible plugs shall be made of a composition conforming to SB-61 or from phosphor-bronze rods conforming to ASTM B 139.

A-20.3 Typical designs of fusible plugs are given in Fig. A-10.

A-20.4 The bore of the casing shall be tapered continuously from the water end of the casing for a distance of at least 1 in. to a diameter of not less than $\frac{3}{8}$ in. (10 mm) at a point not less than $\frac{1}{2}$ in. (13 mm) from the fire end. The diameter of the bore at either end shall be not less than $\frac{1}{2}$ in. (13 mm). The hole on the fire end shall be as large as possible and may be of any shape provided the cross-sectional area at all points is greater than the area of the least cross section of the fusible metal.

A-20.5 A fusible plug shall be of such length that when installed it shall project at least $\frac{3}{4}$ in. (19 mm) on the water side of the plate, tube, or flue. It shall extend through the plate, tube, or flue on the fire side as little as possible but not more than 1 in. (25 mm).

A-20.6 A fire side plug may be designed so as to be inserted by means of a plug type wrench, so as to reduce the projection on the fire side.

A-20.7 If a fire-actuated fusible plug is inserted in a tube, the tube wall *at the plug* shall be not less than 0.22 in. thick, or sufficient to give four full threads.

A-20.8 Fusible plugs that comply with the requirements of A-19 and A-20 must be stamped on the casing with the name of the manufacturer, and on the water end of the fusible metal "ASME Std."

A-20.9 Fusible metal, other than tin as specified in A-19.1, for use under temperatures exceeding 450°F, may be used and the casing may be made of other material and shape than specified in A-20.2 through A-20.4 if the metal and the casing are approved by the administrative authority. Such plugs shall not be marked as "ASME Std."

A-21

Fire-actuated fusible plugs, if used, shall be located at the lowest permissible water level as determined by the boiler Manufacturer; steam-actuated plugs, if used, shall be so located that they will operate when the water level is at the point where a fire-actuated fusible plug would be located.

PROOF TESTS TO ESTABLISH MAXIMUM ALLOWABLE WORKING PRESSURE

A-22

A-22.1 Scope. The maximum allowable working pressure for pressure parts of boilers for which the strength cannot be computed with a satisfactory assurance of accuracy shall be established in accordance with the requirements of this paragraph, using one of the test procedures applicable to the type of loading and to the material used in its construction.

The tests in these paragraphs may be used only for the purpose of establishing the maximum allowable working pressure of those elements or component parts for which the thickness cannot be determined by means of the design rules given in this Code. The maximum allowable working pressure of all other elements or component parts shall not be greater than that determined by means of the applicable design rules.

A-22.2 Tests

A-22.2.1 Types. Provision is made for two types of tests for determining the internal maximum allowable working pressure:

A-22.2.1.1 Tests based on yielding of the part to be tested. These tests are limited to materials with a ratio of minimum specified yield to minimum specified ultimate strength of 0.625 or less.

A-22.2.1.2 Tests based on bursting of the part.

A-22.2.2 Retests. A retest shall be allowed on a duplicate pressure part if errors or irregularities are obvious in the test results.

A-22.2.3 Precautions. Safety of testing personnel should be given serious consideration when conducting proof tests, and particular care should be taken during bursting tests in A-22.6.3.

A-22.3 Pressure

A-22.3.1 Previously Applied. The pressure parts for which the maximum allowable working pressure is to be established shall not previously have been subjected to a pressure greater than $1\frac{1}{2}$ times the desired or anticipated maximum allowable working pressure, adjusted for design temperature as provided in A-22.8.

A-22.3.2 Application. In the procedures given in A-22.6.1 for the Strain Measurement Test, and A-22.6.2 for the Displacement Measurement Test, the hydrostatic

pressure in the pressure part shall be increased gradually until approximately one-half the anticipated maximum allowable working pressure is reached. Thereafter, the test pressure shall be increased in steps of approximately one-tenth or less of the anticipated maximum allowable working pressure until the pressure required by the test procedure is reached. The pressure shall be held stationary at the end of each increment for a sufficient time to allow the observations required by the test procedure to be made, and shall be released to zero to permit determination of any permanent strain or displacement after any pressure increment that indicates an increase in strain or displacement over the previous equal pressure increment.

A-22.4 Critical Areas. As a check that the measurements are being taken on the most critical areas, the Inspector may require a brittle coating to be applied on all areas of probable high stress concentrations in the test procedures given in A-22.6.1 and A-22.6.2. The surfaces shall be suitably clean before the coating is applied in order to obtain satisfactory adhesion. The technique shall be suited to the coating material.

NOTE: Strains should be measured as they apply to membrane stresses and to bending stresses within the following range. It is recognized that high localized and secondary bending stresses may exist in pressure parts designed and fabricated in accordance with these rules. Insofar as practical, design rules for details have been written to hold such stresses at a safe level consistent with experience.

A-22.5 Yield Strength and Tensile Strength. For proof tests based on yielding, A-22.6.1 or A-22.6.2, the yield strength (or yield point for those materials which exhibit that type of yield behavior indicated by a "sharp-kneed" portion of the stress-strain diagram) of the material in the part tested, shall be determined in accordance with the method prescribed in the applicable material specification and as described in ASTM E 8, Tension Testing of Metallic Materials. For proof tests based on bursting, A-22.6.3, the tensile strength instead of the yield strength of the material in the part tested shall be similarly determined.

Yield or tensile strength so determined shall be the average from three or four specimens cut from the part tested after the test is completed. The specimens shall be cut from a location where the stress during the test has not exceeded the yield strength. The specimens shall not be oxygen cut because this might affect the strength of the material.

When excess stock from the same piece of wrought material is available and has been given the same postweld heat treatment as the pressure part, the test specimens may be cut from this excess stock. The specimens shall not be removed by flame cutting or

any other method involving sufficient heat to affect the properties of the specimen.

If yield or tensile strength are not determined by test specimens from the pressure part tested, alternative methods are given in A-22.6.1, A-22.6.2, and A-22.6.3 for evaluation of proof test results to establish the maximum allowable working pressure.

A-22.6 Procedure

A-22.6.1 Strain Measurement Test

A-22.6.1.1 Subject to limitations of A-22.2.1.1, this procedure may be used for pressure parts under internal pressure, constructed of any material permitted to be used under the rules of Section I. Strains shall be measured in the direction of the maximum stress at the most highly stressed parts (see A-22.4) by means of strain gages of any type capable of indicating strains to 0.00005 in./in. Pressure shall be applied as provided in A-22.3.2.

A-22.6.1.2 After each increment of pressure has been applied, readings of the strain gages and the hydrostatic pressure shall be taken and recorded. The pressure shall be released and any permanent strain at each gage shall be determined after any pressure increment that indicates an increase in strain for this increment over the previous equal pressure increment. Only one application of each increment of pressure is required.

A-22.6.1.3 Two curves of strain against test pressure shall be plotted for each gage line as the test progresses, one showing the strain under pressure and one showing the permanent strain when the pressure is removed. The test may be discontinued when the test pressure reaches the value H which will, by the formula, justify the desired working pressure, but shall not exceed the pressure at which the plotted points for the most highly strained gage line reaches the value given below for the material used.

A-22.6.1.3.1 0.2% permanent strain for carbon, low-alloy and high-alloy steels.

A-22.6.1.3.2 0.5% strain under pressure for copper-base alloys.

A-22.6.1.3.3 0.2% permanent strain for nickel alloys.

A-22.6.1.4 The maximum allowable working pressure P in pounds per square inch at test temperature for parts tested under this paragraph shall be computed by one of the following formulas.

A-22.6.1.4.1 If the average yield strength is determined by A-22.5:

$$P = 0.5H \frac{Y_s}{Y_a}$$

A-22.6.1.4.2 If the actual average yield strength is not determined by test specimens:

$$P = 0.4H$$

where

H = hydrostatic test pressure, psi (kPa), at which the test was stopped in accordance with A-22.6.1.3

Y_s = yield strength — specified minimum

Y_a = yield strength — actual average from test specimens

The maximum allowable working pressure at other temperatures shall be determined as provided in A-22.8.

A-22.6.2 Displacement Measurement Test

A-22.6.2.1 Subject to the limitations of A-22.2.1.1 this procedure may be used only for pressure parts under internal pressure, constructed of materials having a definitely determinable yield point. Displacement shall be measured at the most highly stressed parts (see A-22.4) by means of measuring devices of any type capable of measuring to 0.001 in. (0.02 mm). This displacement may be measured between two diametrically opposed reference points in a symmetrical structure, or between a reference point and a fixed base point. Pressure shall be applied as provided in A-22.3.2.

A-22.6.2.2 After each increment of pressure has been applied, readings of the displacement and the hydrostatic pressure shall be taken and recorded. The pressure shall be released and any permanent displacement shall be determined after any pressure increment that indicates an increase in measured displacement for this increment over the previous equal pressure increment. Only one application of each increment is required. Care must be taken to assure that the readings represent only displacements of the parts on which measurements are being made and do not include any slip of the measuring devices or any movement of the fixed base points or of the pressure part as a whole.

A-22.6.2.3 Two curves of displacement against test pressure shall be plotted for each reference point as the test progresses, one showing the displacement under pressure, and one showing the permanent displacement when the pressure is removed. The application

of pressure shall be stopped when it is evident that the curve through the points representing displacement under pressure has deviated from a straight line.

A-22.6.2.4 The pressure coincident with the proportional limit of the material shall be determined by noting the pressure at which the curve representing displacement under pressure deviates from a straight line. The pressure at the proportional limit may be checked from the curve of permanent displacement by locating the point where the permanent displacement begins to increase regularly with further increases in pressure. Permanent deformation at the beginning of the curve that results from the equalization of stresses and irregularities in the material may be disregarded.

The maximum allowable working pressure P in pounds per square inch at test temperature for parts tested under this paragraph shall be computed by one of the following formulas.

A-22.6.2.4.1 If the average yield strength is determined by A-22.5:

$$P = 0.5H \frac{Y_s}{Y_a}$$

A-22.6.2.4.2 In order to eliminate the necessity of cutting tensile specimens and determining the actual yield strength of the material under test, one of the following formulas may be used to determine the maximum allowable working pressure:

A-22.6.2.4.2.1 For carbon steel, meeting an acceptable Code specification, with a specified minimum tensile strength of not over 70,000 psi (480 MPa):

Customary Units

$$P = 0.5H \left(\frac{S}{S + 5,000} \right)$$

SI Units

$$P = 0.5H \left(\frac{S}{S + 34\,000} \right)$$

A-22.6.2.4.2.2 For any material listed in Tables 1A and 1B of Section II, Part D, as acceptable for Section I construction:

$$P = 0.4H$$

where

H = hydrostatic test pressure coincident with the proportional limit of the weakest element of the component part tested, psi (kPa)

Y_s = yield strength — specified minimum

Y_a = yield strength — actual average from test specimens

S = specified minimum tensile strength

When the formula in A-22.6.2.4.2.1 or A-22.6.2.4.2.2 is used, the material in the pressure part shall have had no appreciable cold working or other treatment that would tend to raise the yield strength above the normal.

The maximum allowable working pressure at other temperatures shall be determined as provided in A-22.8.

A-22.6.3 Bursting Tests

A-22.6.3.1 This procedure may be used for pressure parts under internal pressure when constructed of any material permitted to be used under the rules of Section I. The maximum allowable working pressure of any component part proof tested by this method shall be established by a hydrostatic test to failure by rupture of a full-size sample of such pressure part. The hydrostatic pressure at which rupture occurs must be determined. Alternatively, the test may be stopped at any pressure before rupture that will satisfy the requirements for the desired maximum allowable working pressure. The item so tested shall not be used for Code construction.

A-22.6.3.2 The maximum allowable working pressure P in pounds per square inch at test temperature for parts tested under this paragraph shall be computed by one of the following formulas.

A-22.6.3.2.1 Parts constructed of materials other than cast materials: **01**

$$P = \frac{B}{4} \times \frac{S}{(S_a \text{ or } S_m)}$$

A-22.6.3.2.2 Parts constructed of cast iron:

$$P = \frac{B}{6.67} \times \frac{S}{S_b}$$

A-22.6.3.2.3 Parts constructed of nodular iron:



$$P = \frac{Bf}{5} \times \frac{S}{S_b}$$

- 01 **A-22.6.3.2.4** For parts constructed of cast materials, except cast iron and nodular iron:

$$P = \frac{Bf}{4} \times \frac{S}{(S_a \text{ or } S_m)}$$

where

B = bursting test pressure, psi (kPa)

f = casting quality factor as defined in PG-25

S = specified minimum tensile strength (MPa)

S_a = average actual tensile strength of test specimens

S_m = maximum tensile strength of range of specification (MPa)

S_b = minimum tensile strength of test bar (MPa)

For all materials except cast iron and nodular iron, the maximum allowable working pressure at other temperatures shall be determined as provided in A-22.8.

A-22.7 Parts Subject to Collapse

A-22.7.1 Parts of the boiler normally subject to collapse for which specified rules are not provided in this Section shall withstand without excessive deformation a hydrostatic test of not less than three times the desired maximum allowable working pressure.

A-22.7.2 The maximum allowable working pressure at other than test temperatures shall be determined as provided in A-22.8.

A-22.8 Higher Temperatures. The maximum allowable working pressure for pressure parts that are designed for temperatures at which the allowable stress value of the material is less than that at the test temperature shall be determined by the following formula:

$$P_o = P_t \frac{S_o}{S_t}$$

where

P_o = maximum allowable working pressure at design temperature, psi (kPa)

P_t = maximum allowable working pressure at test temperature, psi (kPa)

S_o = maximum allowable stress value at the design temperature, as given in Table 1A or 1B of Section II, Part D, psi (kPa)

S_t = maximum allowable stress value at test temperature as given in Table 1A or 1B of Section II, Part D, psi (kPa)

A-22.9 Duplicate Parts. When the maximum allowable working pressure of a pressure part has been established by a proof test, duplicate parts of the same materials, design and construction need not be proof tested but shall be given the standard hydrostatic test at $1\frac{1}{2}$ times the maximum allowable working pressure. The dimensions and minimum thickness of the structure to be tested should not vary materially from those actually used. A geometrically similar part may be qualified by a series of tests covering the complete size range of the pressure part.

A-22.10 Inspection. Tests to establish the maximum allowable working pressure for pressure parts shall be witnessed and approved by an Authorized Inspector.

A-22.11 Test Gages

A-22.11.1 An indicating gage shall be connected directly to the pressure parts. If the indicating gage is not readily visible to the operator controlling the pressure applied, an additional indicating gage shall be provided where it will be visible to the operator throughout the duration of the test. For large pressure parts, it is recommended that a recording gage be used in addition to indicating gages.

A-22.11.2 Pressure gages used in testing shall comply with PG-99.4.

A-22.11.3 All gages used in proof testing shall be calibrated against a standard deadweight tester or a calibrated master gage before the proof test is begun. Gages shall be recalibrated at any time that there is reason to believe they are in error.

A-24 Table PG-23.1

See Table 1A of Section II, Part D.

A-25 Table PG-23.2

See Table 1B of Section II, Part D.

A-26 Table PG-23.3

See Table 1B of Section II, Part D.

A-27 Table PG-23.4

See Table Y-1 of Section II, Part D.

A-28 Figures PFT-51.1.1–PFT-51.1.7

See Subpart 3, External Pressure Charts in Section II, Part D.

TABLE A-44
GUIDE FOR ESTIMATING STEAMING
CAPACITY BASED ON HEATING SURFACE

	Firetube Boilers	Watertube Boilers
Boiler heating surface		
Hand fired	5	6
Stoker fired	7	8
Oil, gas, or pulverized fuel fired	8	10
Waterwall heating surface		
Hand fired	8	8
Stoker fired	10	12
Oil, gas, or pulverized fuel fired	14	16

GENERAL NOTE: When a boiler is fired only by a gas having a heat value not in excess of 200 Btu/cu ft, the minimum safety valve or safety relief valve relieving capacity may be based on the values given for hand-fired boilers above.

SUGGESTED RULES COVERING EXISTING INSTALLATIONS

A-30

For existing riveted construction, use suggested rules in the 1971 Edition of Section I.

SAFETY VALVES FOR POWER BOILERS

A-44

The minimum safety valve or safety relief valve relieving capacity for other than electric boilers, waste heat boilers, organic fluid vaporizers, and forced-flow steam generators with no fixed steam and waterline, when provided in accordance with PG-67.4.3, may be estimated on the basis of the pounds of steam generated per hour per square foot of boiler heating surface and waterwall heating surface, as given in Table A-44.

In many cases, a greater relieving capacity of safety relief valves will have to be provided than that estimated using Table A-44, in order to meet the requirements of the first paragraph of PG-67.2.

A-45

When boilers of different maximum allowable working pressures with minimum safety valve settings varying more than 6% are so connected that steam can flow toward the lower pressure units, the latter shall be protected by additional safety valve capacity, if necessary, on the lower pressure side of the system. The additional safety valve capacity shall be based

upon the maximum amount of steam that can flow into the lower pressure system. The additional safety valves shall have at least one valve set at a pressure not to exceed the lowest allowable pressure and the other valves shall be set within a range not to exceed 3% above that pressure.

A-46

If the safety valve or safety relief valve capacity cannot be determined or if it is desirable to verify the computations, the capacity may be checked in one of the three following ways, and if found insufficient, additional capacity shall be provided.

A-46.1 By making an accumulation test, that is, by shutting off all other steam-discharge outlets from the boiler and forcing the fires to the maximum. The safety valve equipment shall be sufficient to prevent an excess pressure beyond that specified in PG-67.2. This method should not be used on a boiler with a superheater or reheater or on a high-temperature water boiler.

A-46.2 By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel (see A-12 through A-17).

A-46.3 By determining the maximum evaporative capacity by measuring the feedwater. The sum of the safety valve capacities marked on the valves shall be equal to or greater than the maximum evaporative capacity of the boiler. This method shall not be used on high-temperature water boilers.

A-48

When operating conditions are changed, or additional heating surface such as water screens or waterwalls is connected to the boiler circulation, the safety valve or safety relief valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with PG-67.2. The additional valves required on account of changed conditions may be installed on the piping between the boiler and the main stop valve except when the boiler is equipped with a superheater or other piece of apparatus. In the latter case they may be installed on the piping between the boiler drum and the inlet to the superheater or other apparatus, provided that the piping between the boiler and safety valve (or valves) connection has a cross-sectional area of at least three times the combined areas of the inlet connections to the safety valves applied to it.

A-63.2 During a hydrostatic test of a boiler, the safety valve or valves shall be removed or each valve disk shall be held to its seat by means of a testing clamp and not by screwing down the compression screw upon the spring.

A-64 Repairs to Existing Boilers

Where repairs are necessary that in any way affect the working pressure or safety of a boiler, a state inspector, municipal inspector, or an inspector employed regularly by an insurance company, which is authorized to do a boiler insurance business in the state in which the boiler is used, shall be called for consultation and advice as to the best method of making such repairs; after such repairs are made they shall be subject to the approval of a state inspector, municipal inspector, or an inspector regularly employed by an insurance company that is authorized to do a boiler insurance business in the state in which the boiler is used.

EXAMPLES OF METHODS OF COMPUTATION OF OPENINGS IN VESSEL SHELLS

Application of the rules in PG-32, PG-33, PG-36 through PG-39, PW-15, and PW-16 are given in the following examples. Common assumptions in all the examples are that the design temperature corresponds to the temperature of saturated steam at the maximum allowable working pressure, that all areas are expressed in terms of equivalent area of the vessel material (see PG-37), that the corrosion/erosion allowance is zero, and that all openings are single openings unless otherwise noted. Subscripts have been provided where necessary to eliminate confusion where an algebraic value has more than one meaning as used in these examples. (S_n denotes allowable stress of the nozzle material, S_v denotes allowable stress of the vessel material, R_n denotes radius of nozzle, etc.) The values t and t_n are assumed to be minimum in these examples.

A-65

A boiler shell, designed for 595 psig maximum allowable working pressure, has an inside diameter of 36 in. and is made of $\frac{1}{2}$ in. thick plate. Is it permissible to install an NPS 2 connection by tapping a hole for the pipe directly into the shell?

The NPS 2 connection complies with the pressure-size limitations in PG-39.5.2 and qualifies for the exception provided in PG-32.1.3.1 permitting the opening without requiring a calculation to determine the availability of compensation in the shell. PG-39.5.1 and Table PG-39, however, require a minimum plate thickness and thread engagement greater than that provided by the shell thickness. Therefore, the connection cannot be made as originally stated; however, either a heavier shell plate or a built-up pad or properly attached plate or fitting could be used to provide the minimum metal thickness and number of threads as required by PG-39 and Table PG-39. Should a plate or fitting, attached by welding, be used, the rules in PG-37, PW-15, and PW-16 shall be met.

A-66

A forged steel fitting as shown in Fig. A-66, with a female 3 in. nominal pipe thread over the full fitting depth is to be inserted and welded into a vessel shell. The maximum allowable stress of the fitting material is 15,000 psi and 17,500 psi for the vessel shell material. The maximum allowable working pressure of the vessel is 375 psig. See Fig. A-66 for nozzle and vessel dimensions.

The fitting complies with the size, pressure, and thread depth limitations provided in PG-39.5 and Table PG-39. The welded attachment does not qualify for the exception which would exempt the design from calculation of the required reinforcement as provided in PG-32 and must, therefore, comply with PG-33 as follows.

Minimum required thickness for reinforcement consideration:

$$\begin{aligned} \text{Shell } t_r &= \frac{PR_v}{S_v - (1 - y)P} \\ &= \frac{375 \times 24}{17,500 - (1 - 0.4) \times 375} \\ &= 0.52098 \text{ in.} \end{aligned}$$

$$\begin{aligned} \text{Nozzle } t_{rn} &= \frac{PR_n}{S_n - (1 - y)P} \\ &= \frac{375 \times 1.75}{15,000 - (1 - 0.4) \times 375} \\ &= 0.04442 \text{ in.} \end{aligned}$$

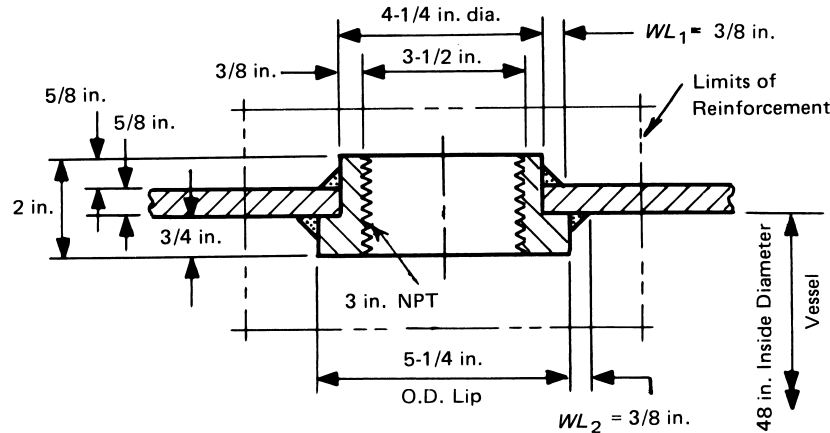


FIG. A-66 EXAMPLE FOR TYPICAL NOZZLE COMPUTATIONS

Area of reinforcement required (see PG-33.2 and PG-37):

$$\begin{aligned}
 A &= 2t_rFR_n + 2t_n t_r [1 - (S_n/S_v)] \\
 &= 2 \times 0.52098 \times 1.0 \times 1.75 + 2 \times 0.375 \times 0.52098 \\
 &\quad \times [1 - (15,000/17,500)] \\
 &= 1.87925 \text{ sq in.}
 \end{aligned}$$

Area of reinforcement available in vessel wall (see PG-36.4.1 and PG-37):

$$\begin{aligned}
 A_1 &= 2R_n(t - F_{t_r}) - 2t_n(t - F_{t_r})[1 - (S_n/S_v)] \\
 &= 2 \times 1.75(0.625 - 1.0 \times 0.52098) \\
 &\quad - 2 \times 0.375(0.625 - 1.0 \times 0.52098) \\
 &\quad \times [1 - (15,000/17,500)] \\
 &= 0.35292 \text{ sq in.}
 \end{aligned}$$

Area of reinforcement available in the nozzle wall external of the vessel (see PG-36.4.2 and PG-37):

In that the actual nozzle projection is less than that permitted within the limits of reinforcement, modification of the equation provided in PG-36.4.2 will be required to reflect the actual area present available for reinforcement.

$$\begin{aligned}
 A_2 &= 2(t_n - t_m)(\text{actual projection}) (S_n/S_v) \\
 &= 2 \times (0.375 - 0.04442) \times 0.625 \times (15,000/17,500) \\
 &= 0.35419 \text{ sq in.}
 \end{aligned}$$

Area of reinforcement available in the nozzle and nozzle lip internal of the vessel (see PG-36.4.2 and PG-37):

$$\begin{aligned}
 A_3 &= (\text{O.D. nozzle lip} - \text{I.D. nozzle}) (\text{actual projection}) (S_n/S_v) \\
 &= (5.25 - 3.5) \times 0.75 \times (15,000/17,500) \\
 &= 1.125 \text{ sq in.}
 \end{aligned}$$

Area of reinforcement available in attachment welds (see PG-36.4.3 and PG-37):

$$\begin{aligned}
 A_4 &= (WL_1^2 + WL_2^2) (S_n/S_v) \\
 &= (0.375^2 + 0.375^2)(15,000/17,500) \\
 &= 0.24107 \text{ sq in.}
 \end{aligned}$$

Total area of reinforcement available:

$$A_1 + A_2 + A_3 + A_4 = 2.07318 \text{ sq in.} \geq A$$

as required for demonstration of compliance with PG-33.

Compliance with PG-37 and PW-15 is demonstrated by the following calculations.

Required minimum strength to be provided by the combined load-carrying elements through each load-carrying path (see PG-37 and PW-15):

$$\begin{aligned}
 W &= dt_r S_v \\
 &= 3.5 \times 0.52098 \times 17,500 \\
 &= 31,910 \text{ lb}
 \end{aligned}$$

Strength of the load-carrying elements in path number 1, per Fig. PW-16, sketch(d) (see PG-37 and PW-15):

Nozzle wall in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi t_n (d + t_n) (\text{factor in PW-15.2}) S_n \\
 &= 0.5 \times 3.14159 \times 0.375 \times (3.5 + 0.375) \\
 &\quad \times 0.7 \times 15,000 \\
 &= 23,967 \text{ lb}
 \end{aligned}$$

External fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_1 (dl + WL_1) (\text{factor in PW-15.2}) S_n \\
 &= 0.5 \times 3.14159 \times 0.375 \times (4.25 + 0.375) \\
 &\quad \times 0.49 \times 15,000 \\
 &= 20,024 \text{ lb}
 \end{aligned}$$

The combined strength of path number 1 equals 43,991 lb $\geq W$ as required for compliance with PG-37 and PW-15.

Strength of the load-carrying elements in path number 3, per Fig. PW-16, sketch (d) (see PG-37 and PW-15):

Nozzle lip in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi (\text{lip thickness}) dl (\text{factor in PW-15.1.5}) S_n \\
 &= 0.5 \times 3.14159 \times 0.75 \times 4.25 \times 0.7 \times 15,000 \\
 &= 52,572 \text{ lb}
 \end{aligned}$$

External fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_1 dl (\text{factor in PW-15.2}) S_n \\
 &= 0.5 \times 3.14159 \times 0.375 \times 4.25 \times 0.49 \times 15,000 \\
 &= 18,400 \text{ lb}
 \end{aligned}$$

The combined strength of path number 3 equals 70,972 lb $\geq W$ as required for compliance with PG-37 and PW-15.

Verification of the minimum weld sizing as required by PW-16.1 and Fig. PW-16.1, sketch (u-2) is demonstrated by the following

Required per Fig. PW-16.1, sketch (u-2):

$$t_1 + t_2 \geq 1.25 t_{\min}$$

$$t_1 \geq 0.25$$

$$t_2 \geq 0.25$$

Actual per Fig. A-66:

$$t_1 = WL_1 \sin 45^\circ$$

$$= 0.375 \times 0.7071$$

$$= 0.26516 \text{ in.}$$

$$t_2 = WL_2 \sin 45^\circ$$

$$= 0.375 \times 0.7071$$

$$= 0.26516 \text{ in.}$$

$$t_{\min} = 0.375 \text{ (based on } t_n \text{)}$$

Verification:

$$(t_1 + t_2 = 0.53032) \geq (1.25 t_{\min} = 0.46875)$$

$$(t_1 = 0.26516) \geq 0.25$$

$$(t_2 = 0.26516) \geq 0.25$$

As verified by the above demonstrations, the design is proved to be in compliance with the requirements of Section I.

A-67

A vessel shell has a studding outlet connection mounted as shown in Fig. A-67. The maximum allowable stress of both the vessel and studding outlet material is 12,500 psi. The maximum allowable working pressure of the design is 325 psig. See Fig. A-67 for vessel and studding outlet dimensions.

The studding outlet conforms to the requirements of PG-39.4, both in arrangement and in tapped stud hole requirements. The welded attachment does not qualify for the exception provided in PG-32 and must therefore comply with PG-33 as follows.

$$\begin{aligned}
 W &= (dlt_r - [(2d - dl)(t - t_r)] + A_s)S_v \\
 &= (7.5 \times 0.79236 - [(2 \times 7.5 - 7.5) \\
 &\quad \times (1.0 - 1.0 \times 0.79236)] + 0.0) \times 12,500 \\
 &= 54,818 \text{ lb}
 \end{aligned}$$

Strength of the load-carrying elements in path number 1, per Fig. PW-16, sketch (a) (see PG-37 and PW-15):
External fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_1 (\text{O.D.}_{\text{pad}} + WL_1)(\text{factor in PW-15.2})S \\
 &= 0.5 \times 3.14159 \times 0.53125 \times (12.5 + 0.53125) \\
 &\quad \times 0.49 \times 12,500 \\
 &= 66,606 \text{ lb}
 \end{aligned}$$

Internal fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_2 (dl - WL_2)(\text{factor in PW-15.2})S \\
 &= 0.5 \times 3.14159 \times 0.75 \times (7.5 - 0.75) \\
 &\quad \times 0.49 \times 12,500 \\
 &= 48,707 \text{ lb}
 \end{aligned}$$

The combined strength of path number 1 equals 115,313 lb $\geq W$ as required for compliance with PG-37 and PW-15.

Verification of the minimum weld sizing as required by PW-16.1 and Fig. PW-16.1, sketch (t) is demonstrated by the following.

Required per Fig. PW-16.1(t):

$$\begin{aligned}
 \text{External fillet weld throat} &\geq \frac{1}{2}t_{\min} \\
 \text{Internal fillet weld throat} &\geq 0.7t_{\min}
 \end{aligned}$$

Actual per Fig. A-67:

External fillet weld throat

$$\begin{aligned}
 &= WL_1 \sin 45^\circ \\
 &= 0.53125 \times 0.7071 \\
 &= 0.37564 \text{ in.}
 \end{aligned}$$

Internal fillet weld throat

$$\begin{aligned}
 &= WL_2 \sin 45^\circ \\
 &= 0.75 \times 0.7071 \\
 &= 0.53032 \text{ in.} \\
 t_{\min} &= 0.75 \text{ (based on PW-16.2)}
 \end{aligned}$$

Verification:

$$(\text{External fillet weld throat} = 0.37564)$$

$$\geq (\frac{1}{2}t_{\min} = 0.375)$$

$$(\text{Internal fillet weld throat} = 0.53032)$$

$$\geq (0.7t_{\min} = 0.525)$$

As verified by the above demonstrations, the design is proved to be in compliance with the requirements of Section I.

A-68

A boiler has an NPS 4 extra-strong pipe connection mounted as shown in Fig. A-68. The maximum allowable stress is 12,000 psi for the pipe material and 13,700 psi for the boiler shell material. The maximum allowable working pressure of the boiler is 250 psig. See Fig. A-68 for pipe and shell dimensions.

Check to determine if the welded attachment qualifies for the exception provided in PG-32.

$$K = \frac{PD}{1.82 St} \quad [\text{see PG-32.1.2, Eq. (2)}]$$

$$= \frac{250 \times 30.875}{1.82 \times 13,700 \times 0.4375}$$

$$= 0.7076 \text{ or } 70.76\%$$

$$Dt = 30.875 \times 0.4375$$

$$= 13.5078$$

From Fig. PG-32, maximum size of opening with inherent compensation is 4.35 in.

Nominal ID of NPS 4 extra strong pipe is:

$$4.5 - 2(0.337) = 3.826 \text{ in.}$$

Since ID is less than maximum size opening from Fig. PG-32, no calculation need be made to demonstrate compliance with the compensation requirements of PG-33 (see PG-32.1.3.2).

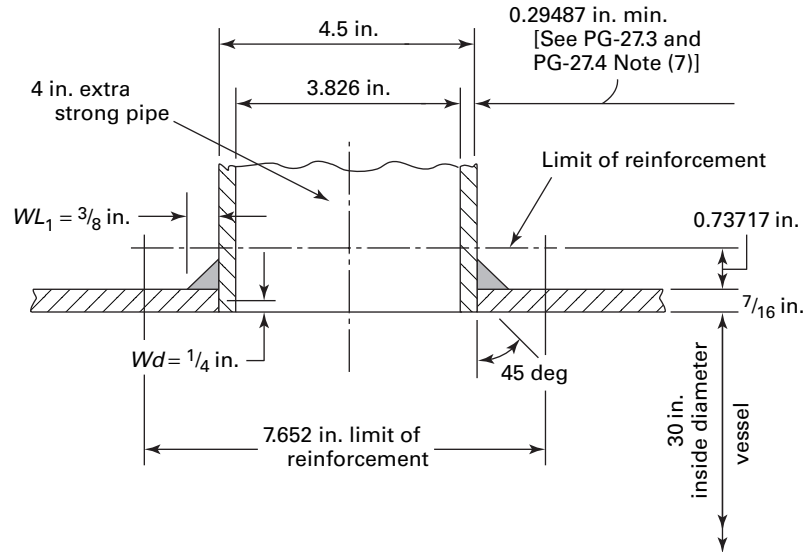


FIG. A-68 EXAMPLE FOR TYPICAL NOZZLE COMPUTATIONS

A-69

A vessel has a series of welded connections in a definite pattern as shown in Fig. A-69. The maximum allowable stress of all nozzle and vessel material is 17,500 psi. The maximum allowable working pressure of the design is 1,500 psig. See Fig. A-69 for all nozzle and vessel dimensions.

The welded attachments do not qualify for the exception provided in PG-32 and must therefore comply with PG-33 as follows.

Minimum required thickness for reinforcement consideration:

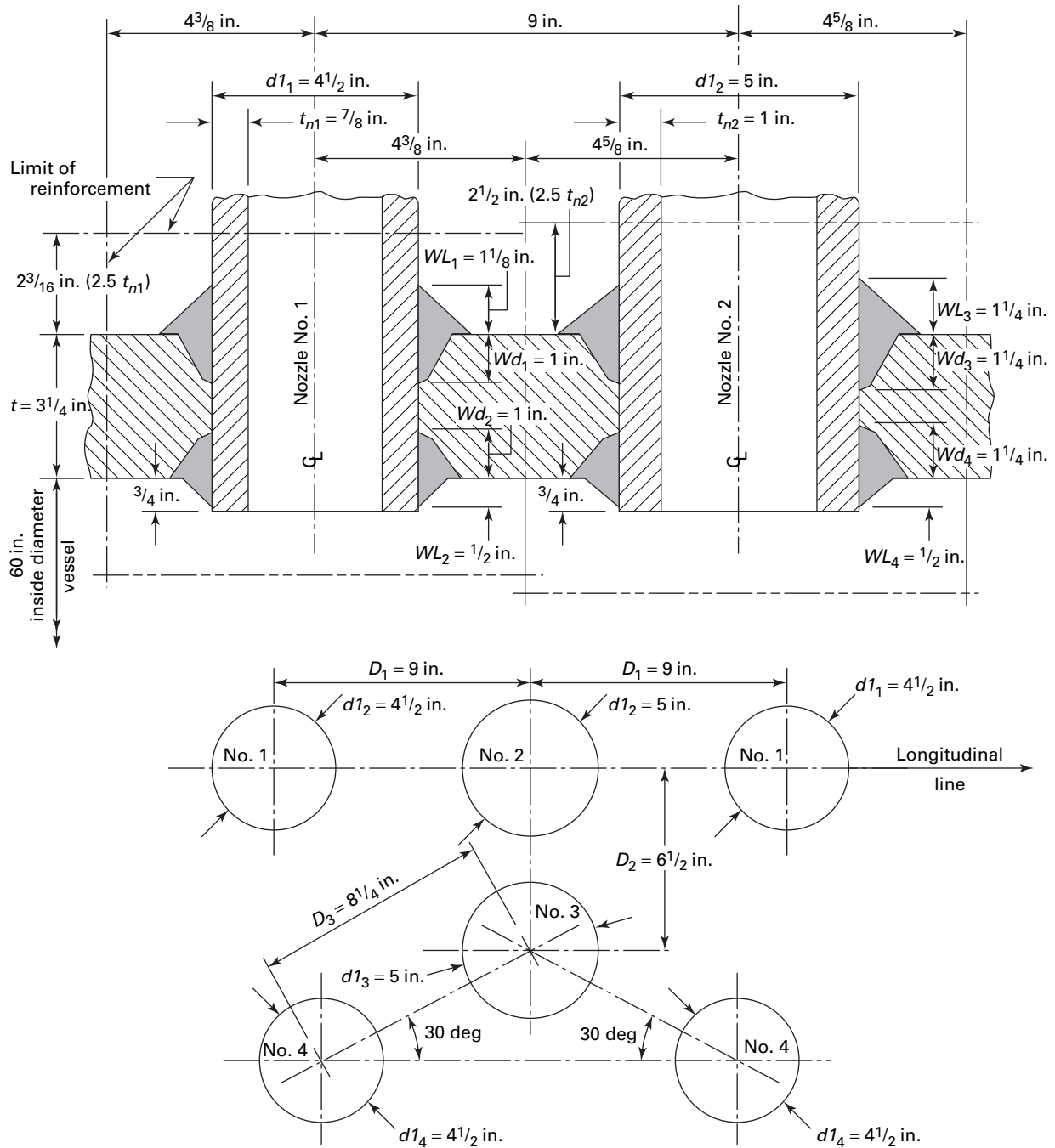
$$\begin{aligned}
 \text{Shell } t_r &= \frac{PR_v}{S_v - (1 - y)P} \\
 &= \frac{1,500 \times 30}{17,500 - (1 - 0.4) \times 1500} \\
 &= 2.71084 \text{ in.} \\
 \text{Nozzle } t_{rn1 \text{ and } 4} &= \frac{P(0.5 dl_1 - t_{n1})}{S_n - (1 - y)P} \\
 &= \frac{1,500(0.5 \times 4.5 - 0.875)}{17,500 - (1 - 0.4) \times 1500} \\
 &= 0.12424 \text{ in.}
 \end{aligned}$$

$$\begin{aligned}
 \text{Nozzle } t_{rn2 \text{ and } 3} &= \frac{P(0.5 dl_2 - t_{n2})}{S_n - (1 - y)P} \\
 &= \frac{1,500(0.5 \times 5 - 1.0)}{17,500 - (1 - 0.4) \times 1500} \\
 &= 0.13554 \text{ in.}
 \end{aligned}$$

The limits of reinforcement on each side of the axis of the openings, as permitted under PG-36.2.2, are:

Minimum longitudinal condition between nozzles 1 and 2

$$\begin{aligned}
 &= \left[\frac{(0.5 dl_1 - t_{n1}) + (0.5 dl_2 - t_{n2})}{2} \right] \\
 &\quad + \left(\frac{t_{n1} + t_{n2}}{2} \right) + t \\
 &= \left[\frac{(0.5 \times 4.5 - 0.875) + (0.5 \times 5 - 1.0)}{2} \right] \\
 &\quad + \left(\frac{0.875 + 1.0}{2} \right) + 3.25 \\
 &= 5.625 \text{ in.} > D_1/2
 \end{aligned}$$



GENERAL NOTE: Nozzles 1 and 4 are identical dimensionally and nozzles 2 and 3 are identical dimensionally.

FIG. A-69 EXAMPLE FOR TYPICAL NOZZLE COMPUTATIONS

Minimum circumferential condition between nozzles 2 and 3

$$\begin{aligned}
 &= \left[\frac{(0.5 dl_2 - t_{n2}) + (0.5 dl_3 - t_{n3})}{2} \right] \\
 &\quad + \left(\frac{t_{n2} + t_{n3}}{2} \right) + t \\
 &= \left[\frac{(0.5 \times 5 - 1.0) + (0.5 \times 5 - 1.0)}{2} \right] \\
 &\quad + \left(\frac{1.0 + 1.0}{2} \right) + 3.25 \\
 &= 5.75 \text{ in.} > D_2 / 2
 \end{aligned}$$

Minimum diagonal condition between nozzles 3 and 4

$$\begin{aligned}
 &= \left[\frac{(0.5 dl_3 - t_{n3}) + (0.5 dl_4 - t_{n4})}{2} \right] \\
 &\quad + \left(\frac{t_{n3} + t_{n4}}{2} \right) + t \\
 &= \left[\frac{(0.5 \times 5 - 1.0) + (0.5 \times 4.5 - 0.875)}{2} \right] \\
 &\quad + \left(\frac{1.0 + 0.875}{2} \right) + 3.25 \\
 &= 5.625 \text{ in.} > D_3 / 2
 \end{aligned}$$

Each of the above conditions is greater than one-half the center-to-center distance, for the condition considered, between the openings; therefore, the rule of PG-38.1 shall apply.

Nozzle 1 and 4 — area of reinforcement required in the longitudinal plane:

$$\begin{aligned}
 A_{l1} &= (dl_1 - 2t_{n1})t_r F \\
 &= (4.5 - 2 \times 0.875) \times 2.71084 \times 1.0 \\
 &= 7.45481 \text{ sq in.}
 \end{aligned}$$

Nozzle 2 and 3 — area of reinforcement required in the longitudinal plane:

$$\begin{aligned}
 A_{l2} &= (dl_2 - 2t_{n2})t_r F \\
 &= (5 - 2 \times 1.0) \times 2.71084 \times 1.0 \\
 &= 8.13252 \text{ sq in.}
 \end{aligned}$$

Nozzle 2 and 3 — area of reinforcement required in the circumferential plane:

$$\begin{aligned}
 A_{c2} &= (dl_2 - 2t_{n2})t_r F \\
 &= (5 - 2 \times 1.0) \times 2.71084 \times 0.5 \\
 &= 4.06626 \text{ sq in.}
 \end{aligned}$$

Nozzle 3 — area of reinforcement required in the diagonal plane:

$$\begin{aligned}
 A_{d3} &= (dl_3 - 2t_{n3})t_r F \\
 &= (5 - 2 \times 1.0) \times 2.71084 \times 0.88 \\
 &= 7.15662 \text{ sq in.}
 \end{aligned}$$

Nozzle 4 — area of reinforcement required in the diagonal plane:

$$\begin{aligned}
 A_{d4} &= (dl_4 - 2t_{n4})t_r F \\
 &= (4.5 - 2 \times 0.875) \times 2.71084 \times 0.88 \\
 &= 6.56023 \text{ sq in.}
 \end{aligned}$$

Area of reinforcement provided in nozzle 1 in the longitudinal plane:

$$\begin{aligned}
 A_1 &= (t - Ft_r)[D_1 + 2t_{n1} - 0.5(dl_1 + dl_2)] \\
 &= (3.25 - 1.0 \times 2.71084) \\
 &\quad \times [9 + 2 \times 0.875 - 0.5 \times (4.5 + 5)] \\
 &= 3.23496 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_2 &= (t_{n1} - t_{m1})5t_{n1} \\
 &= (0.875 - 0.12424) \times 5 \times 0.875 \\
 &= 3.28458 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_3 &= 2t_{n1} \text{ (internal projection)} \\
 &= 2 \times 0.875 \times 0.75 \\
 &= 1.3125 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_4 &= WL_1^2 + WL_2^2 \\
 &= 1.125^2 + 0.5^2 \\
 &= 1.51562 \text{ sq in.}
 \end{aligned}$$

Total area of available reinforcement provided by nozzle 1 in the longitudinal plane:

$$A_1 + A_2 + A_3 + A_4 = 9.34766 \text{ sq in.} \geq A_{I1}$$

as required for demonstration of compliance with PG-33.

Area of reinforcement provided in nozzle 2 in the longitudinal plane:

$$\begin{aligned}
 A_1 &= (t - Ft_r)[D_1 + t_{n2} - 0.5 (dl_2 + dl_1)] \\
 &= (3.25 - 1.0 \times 2.71084) \\
 &\quad \times [9 + 2 \times 1.0 - 0.5 \times (5 + 4.5)] \\
 &= 3.36975 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_2 &= (t_{n2} - t_{rn2}) 5t_{n2} \\
 &= (1.0 - 0.13554) \times 5 \times 1.0 \\
 &= 4.3223 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_3 &= 2t_{n2} \text{ (internal projection)} \\
 &= 2 \times 1.0 \times 0.75 \\
 &= 1.5 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_4 &= WL_3^2 + WL_4^2 \\
 &= 1.25^2 + 0.5^2 \\
 &= 1.8125 \text{ sq in.}
 \end{aligned}$$

Total area of available reinforcement provided by nozzle 2 in the longitudinal plane:

$$A_1 + A_2 + A_3 + A_4 = 11.00455 \text{ sq in.} \geq A_{I2}$$

as required for demonstration of compliance with PG-33.

Area of reinforcement provided in nozzle 2 or 3 in the circumferential plane:

$$\begin{aligned}
 A_1 &= (t - Ft_r)[D_2 + 2t_{n2} - 0.5 (dl_2 + dl_3)] \\
 &= (3.25 - 0.5 \times 2.71084) \\
 &\quad \times [6.5 + 2 \times 1.0 - 0.5(5 + 5)] \\
 &= 6.63103 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_2 &= (t_{n2} - t_{rn2}) 5t_{n2} \\
 &= (1.0 - 0.13554) \times 5 \times 1.0 \\
 &= 4.3223 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_3 &= 2t_{n2} \text{ (internal projection)} \\
 &= 2 \times 1.0 \times 0.75 \\
 &= 1.5 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_4 &= WL_3^2 + WL_4^2 \\
 &= 1.25^2 + 0.5^2 \\
 &= 1.8125 \text{ sq in.}
 \end{aligned}$$

Total area of available reinforcement provided by nozzle 2 or 3 in the circumferential plane:

$$A_1 + A_2 + A_3 + A_4 = 14.26583 \text{ sq in.} \geq A_{c2}$$

as required for demonstration of compliance with PG-33.

Area of reinforcement provided by nozzle 3 in the diagonal plane:

$$\begin{aligned}
 A_1 &= (t - Ft_r)[D_3 + 2t_{n3} - 0.5 (dl_3 + dl_4)] \\
 &= (3.25 - 0.88 \times 2.71084) \\
 &\quad \times [8.25 + 2 \times 1.0 - 0.5(5 + 4.5)] \\
 &= 4.75453 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_2 &= (t_{n3} - t_{rn3}) 5t_{n3} \\
 &= (1.0 - 0.13554) \times 5 \times 1.0 \\
 &= 4.3223 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_3 &= 2t_{n3} \text{ (internal projection)} \\
 &= 2 \times 1.0 \times 0.75 \\
 &= 1.5 \text{ sq in.}
 \end{aligned}$$

$$\begin{aligned}
 A_4 &= WL_3^2 + WL_4^2 = 1.25^2 + 0.5^2 \\
 &= 1.8125 \text{ sq in.}
 \end{aligned}$$

Total area of available reinforcement provided by nozzle 3 in the diagonal plane:

$$A_1 + A_2 + A_3 + A_4 = 12.38933 \text{ sq in.} \geq A_{d3}$$

as required for demonstration of compliance with PG-33.

Area of reinforcement provided in nozzle 4 in the diagonal plane:

$$\begin{aligned} A_1 &= (t - Ft_r)[D_3 + 2t_{n4} - 0.5(dl_4 + dl_3)] \\ &= (3.25 - 0.88 \times 2.71084) \\ &\quad \times [8.25 + 2 \times 0.875 - 0.5(4.5 + 5)] \\ &= 4.53842 \text{ sq in.} \end{aligned}$$

$$\begin{aligned} A_2 &= (t_{n4} - t_{rn4}) 5t_{n4} \\ &= (0.875 - 0.12424) \times 5 \times 0.875 \\ &= 3.28458 \text{ sq in.} \end{aligned}$$

$$\begin{aligned} A_3 &= 2t_{n4} \text{ (internal projection)} \\ &= 2 \times 0.875 \times 0.75 \\ &= 1.3125 \text{ sq in.} \end{aligned}$$

$$\begin{aligned} A_4 &= WL_1^2 + WL_2^2 \\ &= 1.125^2 + 0.5^2 \\ &= 1.51562 \text{ sq in.} \end{aligned}$$

Total area of available reinforcement provided by nozzle 4 in the diagonal plane:

$$A_1 + A_2 + A_3 + A_4 = 10.65112 \text{ sq in.} \geq A_{d4}$$

as required for demonstration of compliance with PG-33.

The rule of PG-38.4 for the minimum required net cross-sectional area between any two finished openings shall apply as follows.

Net area required in longitudinal plane between nozzles 1 and 2:

$$\begin{aligned} nar &= 0.7Ft_rD_1 \\ &= 0.7 \times 1.0 \times 2.71084 \times 9 \\ &= 17.07829 \text{ sq in.} \end{aligned}$$

Net area provided in vessel wall:

$$\begin{aligned} nav &= [D_1 - 0.5(dl_1 + dl_2)]t \\ &= [9 - 0.5 \times (4.5 + 5)] \times 3.25 \\ &= 13.8125 \text{ sq in.} \end{aligned}$$

Net area provided in nozzle wall fused to vessel wall:

$$\begin{aligned} nan &= t_{n1}Wd_1 + t_{n1}Wd_2 + t_{n2}Wd_3 + t_{n2}Wd_4 \\ &= 0.875 \times 1.0 + 0.875 \times 1.0 + 1.0 \times 1.25 \\ &\quad + 1.0 \times 1.25 \\ &= 4.25 \text{ sq in.} \end{aligned}$$

Total net area provided in the longitudinal plane between nozzles 1 and 2:

$$nav + nan = 18.0625 \text{ sq in.} \geq nar \text{ as required for demonstration of compliance with PG-38.4}$$

Net area required in the circumferential plane between nozzles 2 and 3:

$$\begin{aligned} nar &= 0.7Ft_rD_2 \\ &= 0.7 \times 0.5 \times 2.71084 \times 6.5 \\ &= 6.16716 \text{ sq in.} \end{aligned}$$

Net area provided in vessel wall:

$$\begin{aligned} nav &= [D_2 - 0.5(dl_2 + dl_3)]t \\ &= [6.5 - 0.5 \times (5 + 5)] \times 3.25 \\ &= 4.875 \text{ sq in.} \end{aligned}$$

Net area provided in the nozzle wall fused to the vessel wall:

$$\begin{aligned} nan &= Tt_{n2}Wd_3 + t_{n2}Wd_4 + t_{n3}Wd_3 + t_{n3}Wd_4 \\ &= 1.0 \times 1.25 + 1.0 \times 1.25 + 1.0 \times 1.25 \\ &\quad + 1.0 \times 1.25 \\ &= 5 \text{ sq in.} \end{aligned}$$

Total net area provided in the circumferential plane between nozzles 2 and 3:

$$nav + nan = 9.875 \text{ sq in.} \geq nar \text{ as required for demonstration of compliance with PG-38.4}$$

Net area required in the diagonal plane between nozzles 3 and 4:

$$\begin{aligned} nar &= 0.7Ft_rD_3 \\ &= 0.7 \times 0.88 \times 2.71084 \times 8.25 \\ &= 13.77649 \text{ sq in.} \end{aligned}$$

Net area provided in vessel wall:

$$\begin{aligned} n_{av} &= [D_3 - 0.5 (dl_3 + dl_4)]t \\ &= [8.25 - 0.5 \times (5 + 4.5)] \times 3.25 \\ &= 11.375 \text{ sq in.} \end{aligned}$$

Net area provided in the nozzle wall fused to the vessel wall:

$$\begin{aligned} n_{an} &= t_{n3} Wd_3 + t_{n3} Wd_4 + t_{n4} Wd_1 + t_{n4} Wd_2 \\ &= 1.0 \times 1.25 + 1.0 \times 1.25 + 0.875 \times 1.0 \\ &\quad + 0.875 \times 1.0 \\ &= 4.25 \text{ sq in.} \end{aligned}$$

Total net area provided in the diagonal plane between nozzles 3 and 4:

$$n_{av} + n_{an} = 15.625 \text{ sq in.} \geq n_{ar} \text{ as required for demonstration of compliance with PG-38.4}$$

Nozzles 1 and 4 — The required minimum strength to be provided by the combined load-carrying elements through each load-carrying path (see PG-37 and PW-15):

$$\begin{aligned} W &= d_1 t_r S \\ &= 2.75 \times 2.71084 \times 17,500 \\ &= 130,459 \text{ lb} \end{aligned}$$

Strength of the load-carrying elements in path number 1, per Fig. PW-16, sketch (b):

Nozzle wall in shear

$$\begin{aligned} &= \frac{1}{2} \pi t_{n1} (dl_1 - t_{n1}) (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times 0.875 \times (4.5 - 0.875) \times 0.7 \times 17,500 \\ &= 61,034 \text{ lb} \end{aligned}$$

External fillet weld in shear

$$\begin{aligned} &= \frac{1}{2} \pi WL_1 (dl_1 + WL_1) (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times 1.125 \times (4.5 + 1.125) \\ &\quad \times 0.49 \times 17,500 \\ &= 85,237 \text{ lb} \end{aligned}$$

The combined strength of path number 1 equals 146,271 lb $\geq W$ as required for demonstration of compliance with PG-37 and PW-15.

Strength of the load-carrying elements in path number 3, per Fig. PW-16, sketch (b):

Fillet welds in shear

$$\begin{aligned} &= \frac{1}{2} \pi \times (WL_1 + WL_2) dl_1 (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times (1.125 + 0.5) \times 4.5 \times 0.49 \times 17,500 \\ &= 98,495 \text{ lb} \end{aligned}$$

Groove welds in tension

$$\begin{aligned} &= \frac{1}{2} \pi (Wd_1 + Wd_2) dl_1 (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times (1.0 + 1.0) \times 4.5 \times 0.74 \times 17,500 \\ &= 183,076 \text{ lb} \end{aligned}$$

The combined strength of path number 3 equals 281,571 lb $\geq W$ as required for demonstration of compliance with PG-37 and PW-15.

Nozzles 2 and 3 — The required minimum strength to be provided by the combined load-carrying elements through each load-carrying path (see PG-37 and PW-15):

$$\begin{aligned} W &= d_2 t_r S \\ &= 3 \times 2.71084 \times 17,500 \\ &= 142,319 \text{ lb} \end{aligned}$$

Strength of the load-carrying elements in path number 1, per Fig. PW-16, sketch (b):

Nozzle wall in shear

$$\begin{aligned} &= \frac{1}{2} \pi t_{n2} (dl_2 - t_{n2}) (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times 1.0 \times (5 - 1.0) \times 0.7 \times 17,500 \\ &= 76,969 \text{ lb} \end{aligned}$$

External fillet weld in shear

$$\begin{aligned} &= \frac{1}{2} \pi WL_3 (dl_2 + WL_3) (\text{factor in PW-15.2})S \\ &= 0.5 \times 3.14159 \times 1.25 \times (5 + 1.25) \times 0.49 \times 17,500 \\ &= 105,231 \text{ lb} \end{aligned}$$

The combined strength of path number 1 equals 182,200 lb $\geq$ Was required for demonstration of compliance with PG-37 and PW-15.

Strength of the load-carrying elements in path number 3, per Fig. PW-16, sketch (b):

Fillet welds in shear

$$\begin{aligned} &= \frac{1}{2} \pi (WL_3 + WL_4) dl_2 (\text{factor in PW-15.2}) S \\ &= 0.5 \times 3.14159 \times (1.25 + 0.5) \times 5 \times 0.49 \\ &\quad \times 17,500 \\ &= 117,859 \text{ lb} \end{aligned}$$

Groove welds in tension

$$\begin{aligned} &= \frac{1}{2} \pi (Wd_3 + Wd_4) dl_2 (\text{factor in PW-15.2}) S \\ &= 0.5 \times 3.14159 \times (1.25 + 1.25) \times 5 \times 0.74 \\ &\quad \times 17,500 \\ &= 254,273 \text{ lb} \end{aligned}$$

The combined strength of path number 3 equals 372,132 lb $\geq$ Was required for demonstration of compliance with PG-37 and PW-15.

Nozzles 1 and 4 — Verification of minimum weld sizing as required by PW-16.1 and Fig. PW-16.1, sketch (f):

Required per Fig. PW-16.1, sketch (f):

$$\begin{aligned} t_1 + t_2 &\geq 1.25 t_{\min} \\ t_c &\geq 0.25 \\ t_1 &\geq 0.25 \\ t_2 &\geq 0.25 \end{aligned}$$

Actual per Fig. A-69:

$$\begin{aligned} t_1 &= WL_1 \sin 45^\circ \\ &= 1.125 \times 0.7071 \\ &= 0.79548 \text{ in.} \\ t_2 &= Wd_1 + Wd_2 \\ &= 1.0 + 1.0 \\ &= 2 \text{ in.} \end{aligned}$$

$$\begin{aligned} t_c &= WL_2 \sin 45^\circ \\ &= 0.5 \times 0.7071 \\ &= 0.35355 \text{ in.} \end{aligned}$$

$$t_{\min} = 0.75 \text{ in. (based on PW-16.2)}$$

Verification:

$$(t_1 + t_2 = 2.79548) \geq (1.25 t_{\min} = 0.9375)$$

$$(t_c = 0.35355) \geq 0.25$$

$$(t_1 = 0.79548) \geq 0.25$$

$$(t_2 = 2) \geq 0.25$$

Nozzles 2 and 3 — Verification of minimum weld sizing as required by PW-16.1 and Fig. PW-16.1, sketch (f):

Required per Fig. PW-16.1, sketch (f):

$$\begin{aligned} t_1 + t_2 &\geq 1.25 t_{\min} \\ t_c &\geq 0.25 \\ t_1 &\geq 0.25 \\ t_2 &\geq 0.25 \end{aligned}$$

Actual per Fig. A-69:

$$\begin{aligned} t_1 &= WL_3 \sin 45^\circ \\ &= 1.25 \times 0.7071 \\ &= 0.88388 \text{ in.} \end{aligned}$$

$$\begin{aligned} t_2 &= Wd_3 + Wd_4 \\ &= 1.25 + 1.25 \\ &= 2.5 \text{ in.} \end{aligned}$$

$$\begin{aligned} t_c &= WL_4 \sin 45^\circ \\ &= 0.5 \times 0.7071 \\ &= 0.35355 \end{aligned}$$

$$t_{\min} = 0.75 \text{ in. (based on PW-16.2)}$$

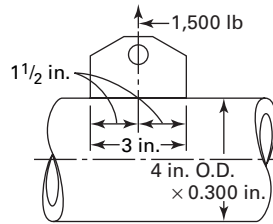


FIG. A-71

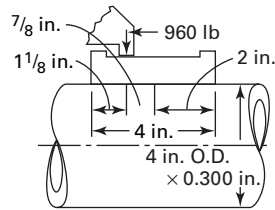


FIG. A-72

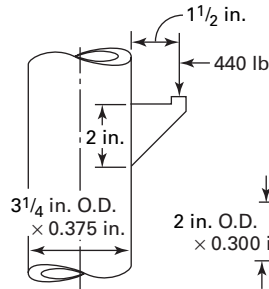


FIG. A-73

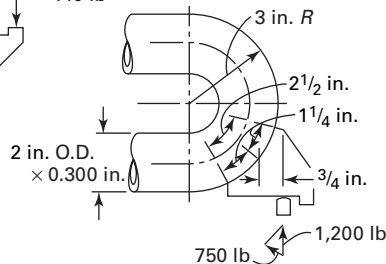


FIG. A-74

FIGS. A-71—A-74 TYPES OF STRUCTURAL ATTACHMENTS TO TUBES

Verification:

$$(t_1 + t_2 = 3.38388) \geq (1.25t_{\min} = 0.9375)$$

$$(t_c = 0.35355) \geq 0.25$$

$$(t_1 = 0.88388) \geq 0.25$$

$$(t_2 = 2.5) \geq 0.25$$

As verified by the above demonstrations, the design is proved to be in compliance with the requirements of Section I.

EXAMPLES OF COMPUTATION OF ALLOWABLE LOADING ON STRUCTURAL ATTACHMENTS TO TUBES

A-71

A tube is suspended by a welded attachment with the loads and dimensions as shown in Fig. A-71. This is a condition of direct radial loading on the tube.

The allowable lug loading is calculated for the following conditions:

material = SA-213-T22

MAWP = 2258 psi

$T = 800^\circ\text{F}$

$D = 4.0$ in.

$t = 0.30$ in.

$1/4$ in. thick lug

7 deg attachment angle

$S_a = 15,000$ psi

$S = 15,000$ psi

$S_t = 2.0 S_a - S = 15,000$ psi

From Table PW-43.1, $K = 1.07$

From Fig. PW-43.1 or PW-43.2.1 or PW-43.2.2

$$X = D/t^2 = 44.4$$

Compression $L_f = 0.0326$

Tension $L_f = 0.0405$

$$L_a = K(L_f)S$$

Compression $L_a = (1.07)(0.0326)(15,000)$
 $= 523$ lb/in.

Tension $L_a = (1.07)(0.0405)(15,000)$
 $= 650$ lb/in.

Actual load:

$W = 1,500$ lb (Tension)

$$L = 1,500 \text{ lb} / 3 \text{ in.} = 500 \text{ lb/in.} < 650 \text{ lb/in.}$$

The loading indicated is therefore within the values allowed by the chart in Fig. PW-43.1.

A-72

A load is supported on a rubbing strip welded to a tube, as shown in Fig. A-72. This problem illustrates a condition where the load is not applied on the center of welded attachment.

The allowable lug loading is calculated for the same conditions given in example A-71:

Compression $L_a = (1.07)(0.0326)(15,000)$
 $= 523$ lb/in.

Tension $L_a = (1.07)(0.0405)(15,000)$
 $= 650$ lb/in.

Allowable unit load P :

$$\frac{D}{t^2} = \frac{4}{0.300^2} = 44.4$$

$P = 660$ lb/in. tension; 555 lb/in. compression

Actual unit load:

$$W = 960 \text{ lb}$$

$$P = \frac{960}{4} \pm \frac{(6 \times 960 \times 0.875)}{2^2} = 240 \pm 315$$

$= 555$ lb/in. compression; 75 lb/in. tension

The actual loading does not exceed values of allowable loading.

A-73

A-73.1 A load is supported from a vertical tube with a welded bracket attachment as shown in Fig. A-73. This example illustrates a condition of eccentric loading where the direct loading is not additive.

The allowable lug loading is calculated for the following conditions:

material = SA-213-T22

MAWP = 3722 psi

$T = 800^\circ\text{F}$

$D = 3.25$ in.

$t = 0.375$ in.

$\frac{1}{4}$ in. thick lug

10 deg attachment angle

$S_a = 15,000$ psi

$S = 15,000$ psi

$S_t = 2.0 S_a - S = 15,000$ psi

From Table PW-43.1, $K = 1.07$

From Fig. PW-43.1, PW-43.2.1, or PW-43.2.2

$$X = D/t^2 = 23.11$$

Compression $L_f = 0.0637$

Tension $L_f = 0.090$

$$L_a = K(L_f)S$$

Compression $L_a = (1.108)(0.0637)(15,000)$
 $= 1,058$ lb/in.

Tension $L_a = (1.108)(0.090)(15,000) = 1,495$ lb/in.

Actual:

$$W = 440 \text{ lb}$$

$$L = \frac{6 \times 440 \times 1.5}{2^2}$$

$$= 990 \text{ lb/in. compression or tension}$$

The actual loading does not exceed values of allowable loading.

A-73.2 To determine the maximum allowable loading on structural attachments to tubes, a test may be conducted on a full-size section of tube with attachment. The test may be considered as meeting the Code requirements provided:

A-73.2.1 The loading applied to the test specimen is at least equivalent to the design loading, and at the same time the tube is subjected to a hydrostatic pressure corresponding to design conditions.

A-73.2.2 The test is conducted in accordance with the requirements of A-22 with the exception that the hydrostatic pressure shall be held at expected design pressure, and the loading on the support shall be increased until permanent set occurs.

A-73.2.3 The maximum load P , allowed on the attachment at or below the pressure corresponding to the hydrostatic pressure, is given by the following formula:

$$P = \frac{HS}{E}$$

where

P = maximum allowable load on attachment, lb

H = test load at the proportional limit of the structure, lb

S = working stress permitted in Table 1A of Section II, Part D, for the tube material at the design temperature that in no case shall be taken at less than 700°F , psi

E = average proportional limit of the tube material, psi

A-74

A superheater section is supported by welded attachment to the short-radius return bend section as shown in Fig. A-74. This example illustrates a condition where



a direct and eccentric load is applied to a bent tube section.

The allowable lug loading is calculated for the following conditions:

material = SA-213-T22

MAWP = 5,087 psi

$T = 700^{\circ}\text{F}$

$D = 2.0$ in.

$t = 0.30$ in.

$\frac{1}{4}$ in. thick lug

15 deg attachment angle

$S_a = 15,000$ psi

$S = 15,000$ psi

$S_t = 2.0 S_a - S = 15,000$ psi

From Table PW-43.1, $K = 1.16$

From Fig. PW-43.1, PW-43.2.1, or PW-43.2.2

$$X = D/t^2 = 22.2$$

Compression $L_f = 0.0664$

Tension $L_f = 0.0948$

For bend:

$$X = (\text{Bend dia})/t^2 = 6/0.3^2 = 66.6$$

From Fig. PW-43.1 or Eqs. PW-43.2.1 or PW-43.2.2

Compression $L_f = 0.0215$

Tension $L_f = 0.0257$

$$L_a = K(\Sigma L_f) 9$$

Compression $L_a = (1.16)(0.0664 + 0.0215)(15,000)$
 $= 1,529$ lb/in.

Tension $L_a = (1.16)(0.0948 + 0.0257)(15,000)$
 $= 2,096$ lb/in.

Actual unit load:

$$P = \frac{750}{2.5} \pm \frac{6 \times 1,200 \times 0.75}{2.5^2}$$

$$= 300 \pm 864 = 1,164 \text{ lb/in. compression; } 564 \text{ lb/in. tension}$$

The actual applied load is less than the values allowed by the chart in Fig. PW-43.1.

PREHEATING

A-100

A-100.1 Preheating may be employed during welding to assist in completion of the welded joint. The need for and the temperature of preheat are dependent on a number of factors such as chemical analysis, degree of restraint of the parts being joined, elevated temperature mechanical properties, and material thicknesses. Mandatory rules for preheating are, therefore, not given in this Section except as required in Table PW-39. As a general guide, some minimum temperatures for preheating are given in A-100.4. It is cautioned that the preheating temperatures listed in A-100.4 do not necessarily ensure satisfactory completion of the welded joint. Requirements for individual materials within the P-Number listing may have preheating requirements more or less restrictive than this general guide. The Welding Procedure Specification for the material being welded shall specify the minimum preheating requirements described in the welding procedure qualification requirements of Section IX.

A-100.2 The heat of welding may assist in maintaining preheat temperatures after the start of welding and, for inspection purposes, temperature measurements may be made near the weld. The method or extent of application of preheat is not, therefore, specifically given. Normally, when materials of two different P-Number groups are joined by welding, the preheat used will be that of the material with the higher preheat specified on the Welding Procedure Specification.

A-100.3 Thicknesses referred to are nominal at the weld for the parts to be joined.

A-100.4 Minimum Temperatures for Preheating

A-100.4.1 P-No. 1, Group No. 1, 2, 3. 175°F (79°C) for material that has both a specified maximum carbon content in excess of 0.30% and a thickness at the joint in excess of 1 in. (25 mm); 50°F (10°C) for all other materials in this grouping.

A-100.4.2 P-No. 3, Group No. 1, 2, 3. 175°F (79°C) for material that has either a specified minimum tensile strength in excess of 70,000 psi (480 MPa) or a thickness at the joint in excess of $\frac{5}{8}$ in. (16 mm); 50°F (10°C) for all other materials in this grouping.

A-100.4.3 P-No. 4, Group No. 1, 2. 250°F (79°C) for material that has either a specified minimum tensile strength in excess of 60,000 psi (410 MPa) or a thickness at the joint in excess of $\frac{1}{2}$ in. (13 mm); 50°F (10°C) for all other materials in this grouping.

A-100.4.4 P-No. 5A, B, C. 400°F (204°C) for material that has either a specified minimum tensile strength in excess of 60,000 psi (410 MPa) or has both a specified minimum chromium content above 6.0% and a thickness at the joint in excess of $\frac{1}{2}$ in. (13 mm); 300°F (149°C) for all other materials in this grouping.

A-100.4.5 P-No. 6, Group No. 1, 2, 3. 400°F (204°C).

A-100.4.6 P-No. 7, Group No. 1, 2. None.

A-100.4.7 P-No. 8, Group No. 1, 2. None.

A-100.4.10 P-No. 10A, Group No. 1. 175°F (79°C).

A-100.4.11 P-No. 10E, Group No. 5. 300°F (149°C) with interpass maintained between 350°F and 450°F (177°C and 232°C).

MAXIMUM ALLOWABLE WORKING PRESSURES — THICK SHELLS

01 A-125 Shells for Internal Pressure

When the thickness of the shell exceeds one-half of the inside radius, the maximum allowable working pressure on the cylindrical shell of a boiler or drum shall be determined by the following formulas:

$$P = SE \frac{Z - 1}{Z + 1}$$

or

$$t = (\sqrt{Z} - 1)R = \left(\frac{\sqrt{Z} - 1}{\sqrt{Z}} \right) R_o$$

where

P = maximum allowable working pressure, psi (kPa)

S = maximum allowable working unit stress, psi (kPa), taken from Table 1A of Section II, Part D

E = efficiency of longitudinal joints or of ligaments between openings:

for fusion welded joints = efficiency specified in PG-27.4, Note 1

for seamless shells = 100% (unity)

for ligaments between openings, the efficiency shall be calculated by the rules given in PG-52

$$\begin{aligned} Z &= (SE + P)/(SE - P) \\ &= [(R + t)/R]^2 \\ &= (R_o/R)^2 \end{aligned}$$

t = minimum thickness of shell plates in weakest course, in. (mm)

R = inside radius of the weakest course of the shell, in. (mm)

R_o = outside radius of the weakest course of the shell, in. (mm)

NOTE: Restrictive requirements of PG-27.2.2 also apply to this paragraph.

ROUNDED INDICATION CHARTS

A-250 Acceptance Standard for Radiographically Determined Rounded Indications in Welds

A-250.1 Applicability of These Standards. These standards are applicable to ferritic, austenitic, and non-ferrous materials.

A-250.2 Terminology

A-250.2.1 Rounded Indications. Indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have tails. When evaluating the size of an indication, the tail shall be included. The indication may be from any imperfection in the weld, such as porosity, slag, or tungsten.

A-250.2.2 Aligned Indications. A sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the center of the two outer rounded indications.

A-250.2.3 Thickness t . t is the thickness of the weld, of the pressure-retaining material, or of the thinner of the sections being joined, whichever is least. If a full penetration weld includes a fillet weld, the thickness of the fillet weld throat shall be included in t .

A-250.3 Acceptance Criteria

A-250.3.1 Image Density. Density within the image of the indication may vary and is not a criterion for acceptance or rejection.

A-250.3.2 Relevant Indications (See Table 1 for Examples). Only those rounded indications which exceed the following dimensions shall be considered relevant.



TABLE 1
MAXIMUM PERMISSIBLE SIZE OF
ROUNDED INDICATION
(Examples Only)

Customary Units				
Thickness <i>t</i> , in.		Maximum Size of Acceptable Rounded Indication, in.		Maximum Size of Nonrelevant Indication, in.
		Random	Isolated	
Less than	$\frac{1}{8}$	$\frac{1}{4}t$	$\frac{1}{3}t$	$\frac{1}{10}t$
	$\frac{1}{8}$	0.031	0.042	0.015
	$\frac{3}{16}$	0.047	0.063	0.015
	$\frac{1}{4}$	0.063	0.083	0.015
	$\frac{5}{16}$	0.078	0.104	0.031
	$\frac{3}{8}$	0.091	0.125	0.031
	$\frac{7}{16}$	0.109	0.146	0.031
	$\frac{1}{2}$	0.125	0.168	0.031
	$\frac{9}{16}$	0.142	0.188	0.031
	$\frac{5}{8}$	0.156	0.210	0.031
	$\frac{11}{16}$	0.156	0.230	0.031
	$\frac{3}{4}$ to 2 incl.	0.156	0.250	0.031
	Over 2	0.156	0.375	0.063
SI Units				
Thickness <i>t</i> , mm		Maximum Size of Acceptable Rounded Indication, mm		Maximum Size of Nonrelevant Indication, mm
		Random	Isolated	
Less than	3.18	$\frac{1}{4}t$	$\frac{1}{3}t$	$\frac{1}{10}t$
	3.18	0.79	1.07	0.38
	4.76	1.19	1.60	0.38
	6.35	1.60	2.11	0.38
	7.94	1.98	2.64	0.79
	9.52	2.31	3.18	0.79
	11.11	2.77	3.71	0.79
	12.70	3.18	4.27	0.79
	14.29	3.61	4.78	0.79
	15.88	3.96	5.33	0.79
	17.46	3.96	5.84	0.79
	19.05 to 50.80 incl.	3.96	6.35	0.79
	Over 50.80	3.96	9.53	1.60

$\frac{1}{10}t$ for t less than $\frac{1}{8}$ in. (3.2 mm)
 $\frac{1}{64}$ in. (0.4 mm) for t $\frac{1}{8}$ in. to $\frac{1}{4}$ in. (6 mm),
 inclusive
 $\frac{1}{32}$ in. (0.8 mm) for t $\frac{1}{4}$ in. (6 mm) to 2 in.
 (51 mm), inclusive
 $\frac{1}{16}$ in. (1.6 mm) for t greater than 2 in.
 (51 mm)

A-250.3.3 Maximum Size of Rounded Indication
 (See Table 1 for Examples). The maximum permissible

size of any indication shall be $\frac{1}{4}t$, or $\frac{5}{32}$ in. (4 mm),
 whichever is smaller; except that an isolated indication
 separated from an adjacent indication by 1 in. (25 mm)
 or more may be $\frac{1}{3}t$, or $\frac{1}{4}$ in. (6 mm), whichever is
 less. For t greater than 2 in. (51 mm) the maximum
 permissible size of an isolated indication shall be in-
 creased to $\frac{3}{8}$ in. (10 mm).

A-250.3.4 Aligned Rounded Indications. Aligned
 rounded indications are acceptable when the summation
 of the diameters of the indications is less than t in a
 length of $12t$. (See Fig. 1.) The length of groups of
 aligned rounded indications and the spacing between
 the groups shall meet the requirements of Fig. 2.

A-250.3.5 Spacing. The distance between adjacent
 rounded indications is not a factor in determining
 acceptance or rejection, except as required for isolated
 indications or groups of aligned indications.

A-250.3.6 Rounded Indication Charts. The
 rounded indications characterized as imperfections shall
 not exceed that shown in the charts.

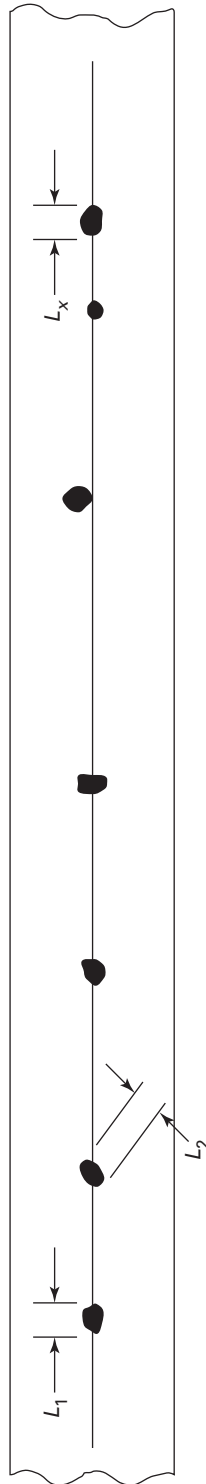
The charts in Fig. 3.1 through Fig. 3.6 illustrate
 various types of assorted, randomly dispersed, and
 clustered rounded indications for different weld thick-
 nesses greater than $\frac{1}{8}$ in. (3.2 mm). These charts
 represent the maximum acceptable concentration limits
 for rounded indications.

The chart for each thickness range represents full-
 scale 6 in. (152 mm) radiographs, and shall not be
 enlarged or reduced. The distributions shown are not
 necessarily the patterns that may appear on the radio-
 graph, but are typical of the concentration and size of
 indications permitted.

**A-250.3.7 Weld Thickness t Less Than $\frac{1}{8}$ in.
 (3.2 mm).** For t less than $\frac{1}{8}$ in. (3.2 mm) the maximum
 number of rounded indications shall not exceed 12 in
 a 6 in. (152 mm) length of weld. A proportionally
 fewer number of indications shall be permitted in welds
 less than 6 in. in length.

A-250.3.8 Clustered Indications. The illustrations
 for clustered indications show up to four times as
 many indications in a local area, as that shown in the
 illustrations for random indications. The length of an
 acceptable cluster shall not exceed the lesser of 1 in.
 or $2t$. Where more than one cluster is present, the sum
 of the lengths of the clusters shall not exceed 1 in.
 (25 mm) in a 6 in. (152 mm) length of weld.

Fig. 1



GENERAL NOTE: Sum of L_1 to L_x shall be less than t in a length of $12 t$.

FIG. 1 ALIGNED ROUNDED INDICATIONS

2001 SECTION I

Fig. 2

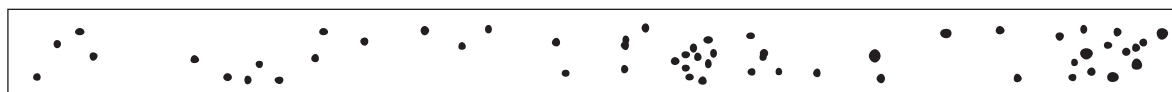


Maximum Group Length
 $L = 1/4$ in. (6 mm) for t less than $3/4$ in. (19 mm)
 $L = 1/3$ in. (19 mm) for t $3/4$ in. (19 mm) to $2 1/4$ in. (57 mm)
 $L = 3/4$ in. (19 mm) for t greater than $2 1/4$ in. (57 mm)

Minimum Group Spacing
 $3L$ where L is the length of the longest adjacent group being evaluated.

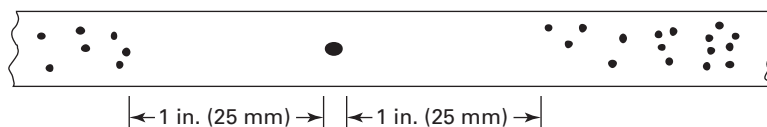
GENERAL NOTE: Sum of the group lengths shall be less than t in a length of $12 t$.

FIG. 2 GROUPS OF ALIGNED ROUNDED INDICATIONS



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld

(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table I)



(c) Cluster

FIG. 3.1 CHARTS FOR $t \frac{1}{8}$ in. (3.2 mm) TO $\frac{1}{4}$ in. (6 mm), INCLUSIVE

METHODS FOR MAGNETIC PARTICLE EXAMINATION (MT)

A-260

A-260.1 Scope. This Appendix provides for procedures that shall be followed whenever magnetic particle examination is required by PG-93. The detailed examination method of Article 7 of Section V shall be used with the acceptance criteria specified in this Appendix. Magnetic particle examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirement of T-150 of Section V.

A-260.2 Certification of Personnel. The Manufacturer shall certify that each magnetic particle examiner meets the following requirements.

(a) The examiner has vision, with correction if necessary, to enable him to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in. and is capable of distinguishing and differentiating contrast between colors used. These capabilities shall be checked annually.

(b) The examiner is competent in the techniques of the magnetic particle examination method for which he is certified, including making the examination and interpreting and evaluating the results, except that where the examination method consists of more than one

operation, he may be certified as being qualified only for one or more of these operations.

A-260.3 Evaluation of Indications. Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones), etc., may produce similar indications.

An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications that have any dimension greater than $\frac{1}{16}$ in. shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

(c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

A-260.4 Acceptance Standards. All surfaces to be examined shall be free of:

- (a) relevant linear indications;
- (b) relevant rounded indications greater than $\frac{3}{16}$ in. (4.8 mm); and
- (c) four or more relevant rounded indications in a line separated by $\frac{1}{16}$ in. (1.6 mm) or less, edge to edge.

METHODS FOR LIQUID PENETRANT EXAMINATION (PT)

NOTE: Satisfactory application of this method of examination requires special skills in the techniques involved and in interpreting the results. The requirements specified herein presume application by suitably experienced personnel.

A-270

A-270.1 Scope. This Appendix provides for procedures that shall be followed whenever liquid penetrant examination is required by PG-93. The detailed examination method of Article 6 of Section V shall be used with the acceptance criteria specified in this Appendix. Liquid penetrant examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirement of T-150 of Section V.

A-270.2 Certification of Personnel. The Manufacturer shall certify that each liquid penetrant examiner meets the following requirements.

(a) The examiner has vision, with correction if necessary, to enable him to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in. (305 mm) and is capable of distinguishing and differentiating contrast between colors used. These capabilities shall be checked annually.

(b) The examiner is competent in the techniques of the liquid penetrant examination method for which he is certified, including making the examination and interpreting and evaluating the results, except that where the examination method consists of more than one operation, he may be certified as being qualified only for one or more of these operations.

01 **A-270.3 Evaluation of Indications.** An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications that have any dimension greater than $\frac{1}{16}$ in. (1.6 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

(c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

01 **A-270.4 Acceptance Standards.** All surfaces to be examined shall be free of:

(a) relevant linear indications;

(b) relevant rounded indications greater than $\frac{3}{16}$ in. (4.8 mm); and

(c) four or more relevant rounded indications in a line separated by $\frac{1}{16}$ in. (1.6 mm) or less, edge to edge.

QUALITY CONTROL SYSTEM

A-300

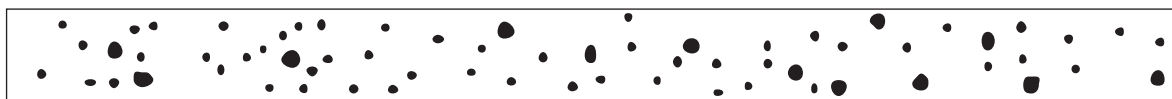
A-301 General

A-301.1 Quality Control System. The Manufacturer or assembler shall have and maintain a quality control system which will establish that all Code requirements, including material, design, fabrication, examination (by the Manufacturer) and inspection of boilers and boiler parts (by the Authorized Inspector), will be met. Provided that Code requirements are suitably identified, the system may include provisions for satisfying any requirements by the Manufacturer or user which exceed minimum Code requirements and may include provisions for quality control of non-Code work. In such systems, the Manufacturer may make changes in parts of the system which do not affect the Code requirements without securing acceptance by the Authorized Inspector. Before implementation, revisions to quality control systems of Manufacturers and Assemblers of safety and safety relief valves shall have been found acceptable to an ASME designee if such revisions affect Code requirements.

The system that the Manufacturer or assembler uses to meet the requirements of this Section must be one suitable for his own circumstances. The necessary scope and detail of the system shall depend on the complexity of the work performed and on the size and complexity of the Manufacturer's (or assembler's) organization. A written description of the system the Manufacturer or assembler will use to produce a Code item shall be available for review. Depending upon the circumstances, the description may be brief or voluminous.

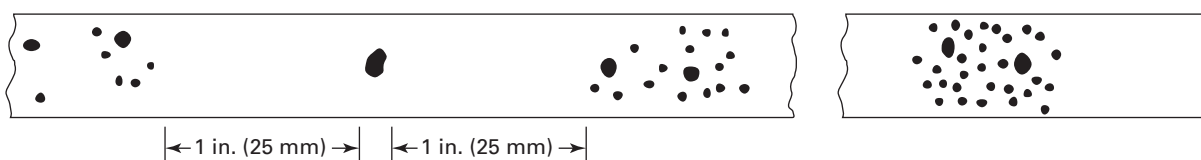
The written description may contain information of proprietary nature relating to the Manufacturer's (or assembler's) processes. Therefore, the Code does not require any distribution of this information, except for the Authorized Inspector or ASME designee.

It is intended that information learned about the system in connection with evaluation will be treated as confidential and that all loaned descriptions will be returned to the Manufacturer upon completion of the evaluation.



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld

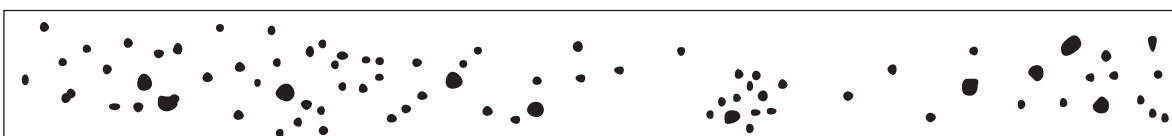
(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table I)

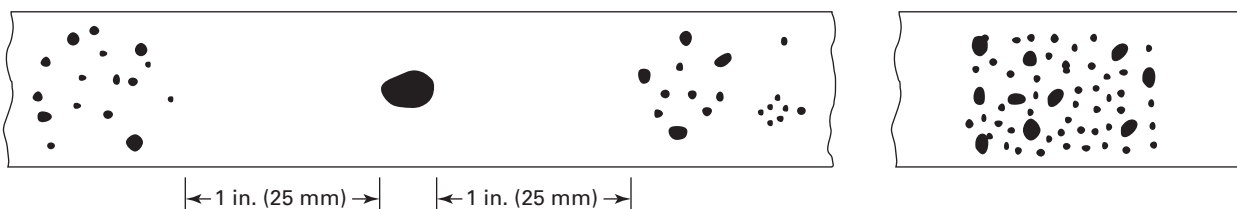
(c) Cluster

FIG. 3.2 CHARTS FOR t OVER $\frac{1}{4}$ in. (6 mm) TO $\frac{3}{8}$ in. (10 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld

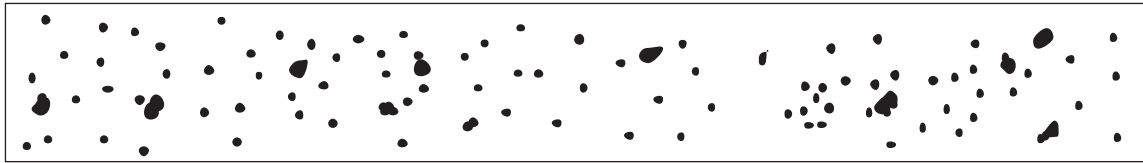
(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table I)

(c) Cluster

FIG. 3.3 CHARTS FOR t OVER $\frac{3}{8}$ in. (10 mm) TO $\frac{3}{4}$ in. (19 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld.

(a) Random Rounded Indications

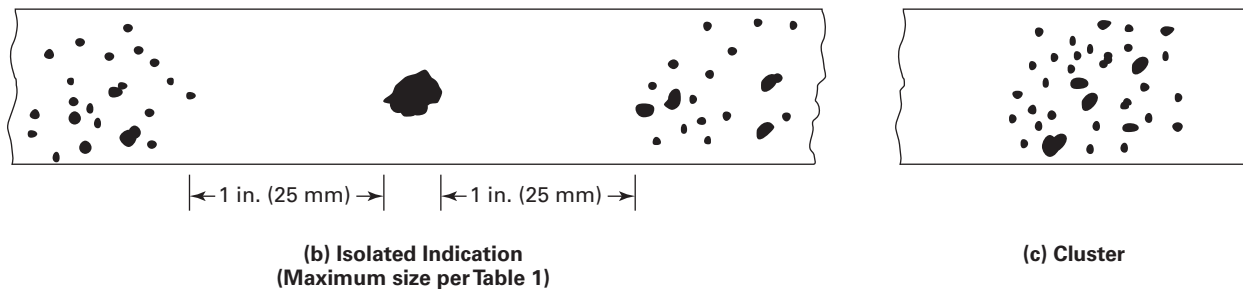


FIG. 3.4 CHARTS FOR t OVER $\frac{3}{4}$ in. (19 mm) TO 2 in. (51 mm), INCLUSIVE

A-302 Outline of Features to Be Included in the Written Description of the Quality Control System

The following is a guide to some of the features that should be covered in the written description of the quality control system and that is equally applicable to both shop and field work.

A-302.1 Authority and Responsibility. The authority and responsibility of those in charge of the quality control system shall be clearly established. Persons performing quality control functions shall have sufficient and well-defined responsibility, the authority, and the organizational freedom to identify quality control problems and to initiate, recommend, and provide solutions.

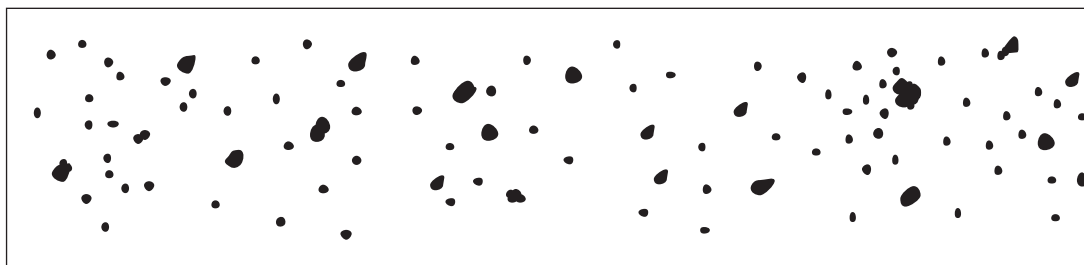
A-302.2 Organization. An organization chart showing the relationship between management and engineering, purchasing, manufacturing, field assembling, inspection, and quality control, is required to reflect the actual organization. The purpose of this chart is to identify and associate the various organizational groups with the particular function for which they are responsible. The Code does not intend to encroach on the Manufacturer's right to establish, and from time

to time to alter, whatever form of organization the Manufacturer considers appropriate for its Code work.

A-302.3 Drawings, Design Calculations, and Specification Control. The Manufacturer's or assembler's quality control system shall provide procedures which will assure that the latest applicable drawings, design calculations, specifications and instructions, required by the Code, as well as authorized changes, are used for manufacture, assembly, examination, inspection, and testing.

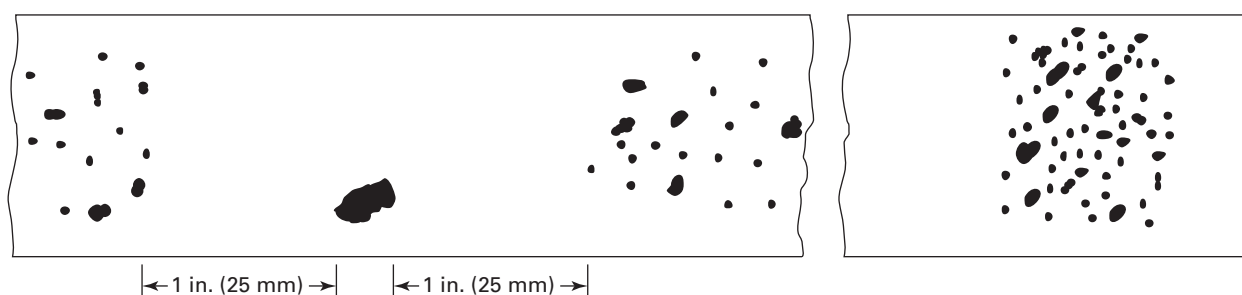
A-302.4 Material Control. The Manufacturer or assembler shall include a system of receiving control that will insure that the material received is properly identified and has documentation, including required material certifications or material test reports, to satisfy Code requirements as ordered. The material control system shall insure that only the intended material is used in Code construction.

A-302.5 Examination and Inspection Program. The Manufacturer's quality control system shall describe the fabrication operations, including examinations, sufficiently to permit the Authorized Inspector to determine at what stages specific inspections are to be performed.



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld.

(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table I)

(c) Cluster

FIG. 3.5 CHARTS FOR t OVER 2 in. (51 mm) TO 4 in. (102 mm), INCLUSIVE

A-302.6 Correction of Nonconformities. There shall be a system agreed upon with the Authorized Inspector for correction of nonconformities. A nonconformity is any condition that does not comply with the applicable rules of this Section. Nonconformities must be corrected or eliminated in some way before the completed component can be considered to comply with this Section.

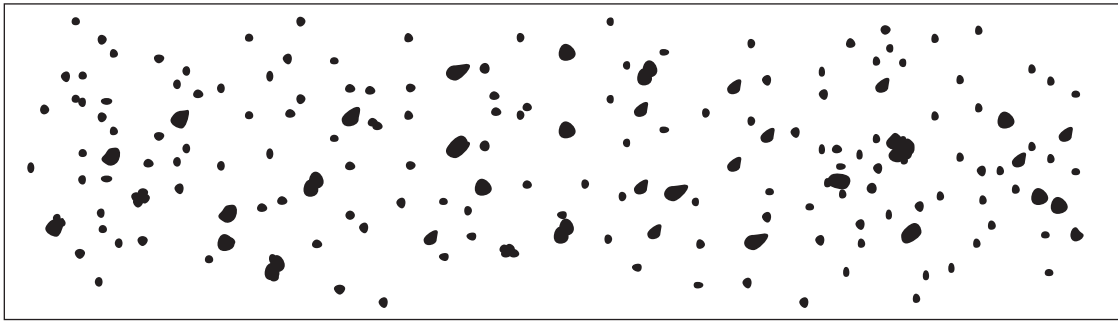
A-302.7 Welding. The quality control system shall include provisions for indicating that welding conforms to requirements of Section IX as supplemented by this Section. Manufacturers intending to use AWS Standard Welding Procedures shall describe control measures used to assure that the welding meets the requirements of this Section (see PW-1.2) and Section IX.

A-302.8 Nondestructive Examination. The quality control system shall include provisions for identifying nondestructive examination procedures the Manufacturer will apply to conform with requirements of this Section.

A-302.9 Heat Treatment. The quality control system shall provide controls to assure that heat treatments as required by the rules of this Section are applied. Means shall be indicated by which the Authorized Inspector can satisfy himself that these Code heat treatment requirements are met. This may be by review of furnace time-temperature records or by other methods as appropriate.

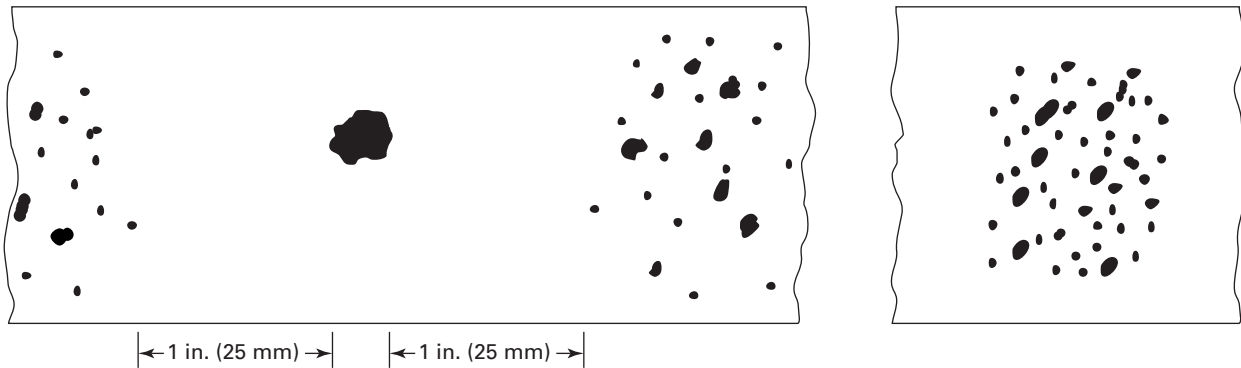
A-302.10 Calibration of Measurement and Test Equipment. The Manufacturer or assembler shall have a system for the calibration of examination, measuring, and test equipment used in fulfillment of requirements of this Section.

A-302.11 Records Retention. The Manufacturer or assembler shall have a system for the maintenance of radiographs and Manufacturers' Data Reports as required by this Section.



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (152 mm) length of weld.

(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table I)

(c) Cluster

FIG. 3.6 CHARTS FOR t OVER 4 in. (102 mm)

A-302.12 Sample Forms. The forms used in the quality control system and any detailed procedures for their use shall be available for review. The written description shall make necessary references to these forms.

A-302.13 Inspection of Boilers and Boiler Parts

A-302.13.1 Inspection of boilers and boiler parts shall be by the Authorized Inspector described in PG-91.

A-302.13.2 The written description of the quality control system shall include reference to the Authorized Inspector.

A-302.13.2.1 The Manufacturer (or assembler) shall make available to the Authorized Inspector at the Manufacturer's plant (or construction site) a current copy of the written description or the applicable quality control system.

A-302.13.2.2 The Manufacturer's quality control system shall provide for the Authorized Inspector at the Manufacturer's plant to have access to all drawings, calculations, specifications, procedures, process sheets, repair procedures, records, test results, and any other documents as necessary for the Inspector to perform his duties in accordance with this Section. The Manufacturer may provide such access either to his own files of such documents or by providing copies to the Inspector.

A-302.14 Inspection of Safety and Safety Relief Valves

A-302.14.1 Inspection of safety and safety relief valves shall be by designated representative of the ASME, as described in PG-73.3.

A-302.14.2 The written description of the quality control system shall include reference to the ASME designee.

A-302.14.2.1 The valve Manufacturer (or assembler) shall make available to the ASME designee at the Manufacturer's plant a current copy of the written description of the applicable quality control system.

A-302.14.2.2 The valve Manufacturer's (or assembler's) quality control system shall provide for the ASME designee to have access to all drawings, calculations, specifications, procedures, process sheets, repair procedures, records, test results, and any other documents as necessary for the designee to perform his duties in accordance with this Section. The Manufacturer may provide such access either to his own files of such documents or by providing copies to the designee.

A-310 ACCEPTANCE OF TESTING LABORATORIES AND AUTHORIZED OBSERVERS FOR CAPACITY CERTIFICATION OF SAFETY AND SAFETY RELIEF VALVES

A-311 Scope

These rules cover the requirements for ASME acceptance of testing laboratories and Authorized Observers for conducting capacity certification tests of safety and safety relief valves.

A-312 Test Facilities and Supervision

The tests shall be conducted at a place where the testing facilities, methods, procedures, and person supervising the tests (Authorized Observer) meet the applicable requirements of ASME PTC 25-1994, Pressure Relief Devices. The tests shall be made under the supervision of and certified by the Authorized Observer. The testing facilities, methods, procedures, and the qualifications of the Authorized Observer shall be subject to the acceptance of the ASME Boiler and Pressure Vessel Committee on recommendation of an ASME designee. Acceptance of the testing facility is subject to review within each 5 year period. The testing laboratory shall have available for reference a copy of ASME PTC 25-1994 and Section I.

A-313 Acceptance of Testing Facility

Before recommendation is made to the ASME Boiler and Pressure Vessel Committee on the acceptability of a testing facility, an ASME designee shall review the applicant's quality control system and testing facility, and shall witness test runs. Before a favorable recommendation can be made to the Committee, the testing facility must meet all applicable requirements of ASME PTC 25-1994. Uncertainty in final flow measurement results shall not exceed $\pm 2\%$. To determine the uncertainty in final flow measurements, the results of flow tests on an object tested at the applicant's testing laboratory will be compared to flow test results on the same object tested at the National Board Testing Laboratory.

A-314 Quality Control System of Testing Laboratory

The applicant shall prepare a Quality Control Manual describing his quality control system which shall clearly establish the authority and responsibility of those in

charge of the quality control system. The manual shall include a description of the testing facility, testing arrangements, pressure, size and capacity limitations, and the testing medium used. An organization chart showing the relationship among the laboratory personnel is required to reflect the actual organization.

The Quality Control Manual shall include, as a minimum, the applicable requirements of this Section and ASME PTC 25-1994, including but not limited to, a description of the Quality Control Manual and document control, the procedure to be followed when conducting tests, the methods by which test results are to be calculated, how test instruments and gages are to be calibrated, and methods of identifying and resolving nonconformities. Sample forms shall be included. If testing procedure specifications or other similar documents are referenced, the Quality Control Manual shall describe the methods of their approval and control.

A-315 Testing Procedures

(a) Flow tests shall be conducted at the applicant's facility, including the testing of one or more valves and other flow devices (nozzle orifice or other object with a fixed flow path) in accordance with the methods specified by this Section and ASME PTC 25-1994. The capacity of the devices to be tested shall fall within the testing capability of the laboratory being evaluated and the National Board Testing Laboratory. The ASME designee will observe the procedures and methods of tests, and the recording of results.

(b) The devices tested at the applicant's facility will then be tested at the National Board Testing Laboratory in Columbus, Ohio, to confirm the test results obtained. Agreement between the results of the two laboratories shall be within $\pm 2\%$. The purpose of comparing test results at the two laboratories is not only to check procedures but also all test instruments and equipment of the applicant's facility over the capacity and pressure range proposed. Since the capabilities of each laboratory are different, no specific number of tests can be predetermined. The number will be in accordance with the flow capability and measurement techniques available at the laboratory being evaluated. Provided the above tests and comparisons are found acceptable, the ASME designee will submit a report to the Society recommending the laboratory be accepted for the purpose of conducting capacity certification tests. If a favorable recommendation cannot be given, the ASME designee will provide, in writing to the Society, the reasons for such a decision.

A-316 Authorized Observers

An ASME designee shall review and evaluate the experience and qualifications of persons who wish to be designated as Authorized Observers. Following such review and evaluation the ASME designee shall make a report to the Society. If a favorable recommendation is not made, full details shall be provided in the report.

Persons designated as Authorized Observers by the ASME Boiler and Pressure Vessel Committee shall supervise capacity certification tests only at testing facilities specified by the Committee.

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DATA REPORT FORMS AND GUIDES

A-350 GUIDES FOR COMPLETING MANUFACTURERS' DATA REPORT FORMS

Immediately following each of the included Data Report Forms (P-2, P-2A, P-3, P-3A, P-4, P-4A, P-4B, P-5, and P-7) is a guide for completing that form. The explanations included in the guides are keyed to the Data Report Forms in the following manner:

- ① Circled numbers on each of the forms refer to the items listed on the applicable guide.
- 1 Numbers without circles appearing in the guide identify specific line or item numbers of the form.

No guide is provided for completing Form P-6, Manufacturers' Data Report Supplementary Sheet.

Appendix A-357 is a guide for determining the Data Report Forms required for Section I construction.

**FORM P-2 MANUFACTURERS' DATA REPORT FOR ALL TYPES OF BOILERS
EXCEPT WATERTUBE AND ELECTRIC
As Required by the Provisions of the ASME Code Rules, Section I**

1. Manufactured by _____		(1)					
(Name and address of Manufacturer)							
2. Manufactured for _____		(2)					
(Name and address of purchaser)							
3. Location of Installation _____		(3)					
(Name and address)							
4. Type _____	Boiler No. _____	(4) (5) (5) (5) (6)					
(HRT, etc.)	(Mfr's. Serial No.) (CRN) (Drawing No.) (Nat'l Board No.)						
5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to Section I of the ASME Boiler and Pressure Vessel Code _____							
Addenda to _____		(7) (8) (Year)					
(Date)		(Numbers)					
Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors are attached for the following items of this report:							
_____		(9)					
(Name of part, item number, mfr's. name and identifying stamp)							
6. Shells or drums: _____							
(no.)	(mat'l. spec. gr.)	(10) (11)					
[thickness (in.)]	[dia (ID)]	(length, inside) [dia (ID)] (length, inside)					
7. Joints: _____							
(12)	(13)	(14)					
[long (seamless, welded)]	[efficiency (as compared to seamless)]	[girth (seamless, welded)] (no. of shell courses)					
8. Heads _____							
(Material Specification No.: Thickness — Flat, Dished, Ellipsoidal — Radius of Dish)							
9. Tubesheet _____		(11)					
(Mat'l. Spec., Grade, Thickness)	Tube Holes	(Dia)					
10. Boiler Tubes: No. _____							
(Mat'l. Spec., Grade)	(Straight or Bent)						
Dia _____	Length _____	Gauge _____					
(If various, give max & min)	(or thickness)						
11. Furnace No. _____							
(19)	Size _____	Length, each section _____					
(O.D. or W x H)	(18)	Total _____					
Type _____							
(17)	(Plain, Adamson, Ring Reinforced, Corrugated, Combined, or Stayed)						
(11)	Seams: Type _____	(12)					
(Mat'l. Spec., Grade, Thickness)	(Seamless, Welded)						
12. Staybolts: No. _____							
Size _____	(18) (11) (19)						
(Dia, Mat'l. Spec. Grade, Size Telltale, Net Area)							
Pitch _____	MAWP _____	(20) psi.					
(Hor. and Vert.)							
13. Stays or braces:							
Location	Material Spec. No.	Type	No. and Size	Max. Pitch	Fig. PFT-32 L/I	Dist. Tubes to Shell	MAWP, psi
(a) F.H. above tubes	(11)	(21)			(23)	(23)	(23)
(b) R.H. above tubes							
(c) F.H. below tubes							
(d) R.H. below tubes							
(e) Through stays							
(f) Dome braces							
14. Other Parts. 1. _____							
(24)	2. _____	3. _____					
(Brief Description — i.e., Dome, Boiler Piping, etc.)							
1. _____	(25) (11)						
2. _____							
3. _____							
(Mat'l. Spec., Grade, Size, Material Thickness, MAWP)							

This form (E00068) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

Form P-2 (Back)

15. Openings: (a) Steam _____ (No., Size, and Type) (b) Safety Valve _____ (No., Size, and Type)
 (c) Blowoff _____ (No., Size, Type, and Location) (d) Feed _____ (No., Size, Type, and Location)
 (e) Manholes: No. _____ Size _____ Location _____
 (f) Handholes: No. _____ Size _____ Location _____

16. Fusible Plug (if used) _____ (No., Dia, Location, Mfr's. Stamp)

17. Boiler Supports: No. _____ Type _____ Attachment _____ (Saddles, Legs, Lugs) (Bolted or Welded)

18. MAWP _____ psi Based On _____ Heating Surface _____ sq ft
 (Code Par. and/or Formula) (Total)

19. Shop Hydrostatic Test _____ psig. 20. Maximum Designed Steaming Capacity _____ lb/hr

21. Remarks _____

31 **CERTIFICATE OF SHOP COMPLIANCE**

We certify that the statements made in this data report are correct and that all details of design, material, construction, and workmanship of this boiler conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization no. _____ to use the (S) _____ symbol expires _____
 Date _____ Signed _____ Name _____
 (Authorized Representative) (Manufacturer)

23 **CERTIFICATE OF SHOP INSPECTION**

Boiler constructed by _____ at _____
 I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the state or province of _____ and employed by _____

_____ have inspected parts of this boiler referred to as data items _____
 _____ and have examined Manufacturer's Partial Data Reports for items _____
 _____ and state that, to the best of my knowledge and belief, the manufacturer has constructed this boiler in accordance with Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

By signing this certificate neither the inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

38 **CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE**

We certify that the field assembly construction of all parts of this boiler conforms with the requirements of SECTION I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization no. _____ to use the (A) or (S) _____ symbol expires _____
 Date _____ Signed _____ Name _____
 (Authorized Representative) (Assembler)

Form P-2 (Back Cont'd)

④ CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the state or province of _____ ③④ _____ and employed by _____

have compared statements in this Manufacturer's Data Report with the described boiler and state that the parts referred to as data items _____ ④① _____, not included in the certificate of shop inspection, have been inspected by me and that to the best of my knowledge and belief the manufacturer and/or the assembler has constructed and assembled this boiler in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE. The described boiler was inspected and subjected to a hydrostatic test of _____ psi.

By signing this certificate neither the inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____ ③⑦ _____
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]



A-351 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT, FORM P-2 (See PG-112.2.1)

- ① Name and address of Manufacturer, i.e., maker of all components not covered by Partial Data Reports.
- ② Name and address of purchaser and/or owner.
- ③ Name and address of location where boiler is to be installed. If not known, so indicate (e.g., "Not known—built for stock").
- ④ Show type of boiler documented by this Data Report.
- ⑤ Identification of boiler by applicable numbers. If intended for installation in Canada, indicate the Canadian Design Registration Number and drawing number.
- ⑥ Year in which fabrication was completed in shop.
- ⑦ Date (year) of Section I Edition under which boiler was constructed.
- ⑧ Issue date of most recent Addenda to Section I under which boiler was constructed (e.g., "1990").
- ⑨ To be completed when one or more components comprising the boiler are furnished by others and certified by Partial Data Report(s), Form P-4.
- ⑩ Show quantity and inside dimensions in inches. If more than two shells or drums are used, enter data in Line 14.
- ⑪ Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-285-B"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.
- ⑫ Indicate type of joint(s).
- ⑬ Show joint efficiency for welded joints.
- ⑭ Same as ⑫ above.
- ⑮ Show number of furnaces in boiler.
- ⑯ For cylindrical furnaces of the Adamson, ring reinforced, and combined types, show length of each section and total length. For other types, show total length only.
- ⑰ For stayed (firebox) type furnace, also complete Line 12.
- ⑱ If threaded, show diameter at root of thread.
- ⑲ Minimum cross-sectional area after deducting for telltale hole.
- ⑳ Maximum allowable working pressure for the stayed area calculated according to the rules contained in Part PFT.
- ㉑ Type of stay or brace, e.g., diagonal, girder, through, etc.
- ㉒ Deleted.
- ㉓ See applicable paragraphs and figures in Part PFT.
- ㉔ List parts not covered elsewhere on the Data Report. If insufficient space, attach a supplementary sheet (Form P-6).
- ㉕ Tabulate data for parts listed on Line 14.
- ㉖ Show data for main, auxiliary steam outlets, and feedline connections only. Does not apply to small openings for water columns, controls, vents, drains, instrumentation, or to openings for connections internal to the boiler such as risers, downtakes, or downcomers.
- ㉗ Maximum allowable working pressure established in accordance with PG-21.
- ㉘ Show Section I paragraph which applies to the weakest part of the boiler as established by calculation or deformation test.
- ㉙ Boiler heating surface calculated in accordance with PG-70.
- ㉚ Hydrostatic pressure applied in accordance with PG-99 and witnessed by the Authorized Inspector.
- ㉛ To be completed and signed by an authorized representative of the Manufacturer.
- ㉜ Show Manufacturer's ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ㉝ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection.

- ③④ To determine what goes in the space, you should be guided by the following:
National Board Stamped Boilers and Pressure Vessels (see Form P-2 Line 4)
 After “and/or State or Province” in the certification blocks—
 If the Inspector has a valid commission for the state or province where the Manufacturer’s shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.
- Boilers and Pressure Vessels Not Stamped National Board*
 Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector’s signature at the bottom of the block.
- ③⑤ Indicate in this space the data items covered on Form P-2 on Lines 6 through 20.
- ③⑥ Indicate by Line numbers those items furnished by other and for which Partial Data Reports (Form P-4) have been examined.
- ③⑦ The Inspector’s National Board commission number must be shown when the boiler is stamped National Board; otherwise show only his state or province commission number. (See ③④ above.)
- ③⑧ To be completed when applicable, and signed by an authorized representative of the organization responsible for field assembly of the boiler.
- ③⑨ Show assembler’s ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ④① This certificate to be completed by the Authorized Inspection Agency representative who performs the field assembly inspection.

FORM P-2A MANUFACTURERS' DATA REPORT FOR ALL TYPES OF ELECTRIC BOILERS **As Required by the Provisions of the ASME Code Rules, Section I**

PART I — To Be Completed by the Manufacturer of the Boiler Pressure Vessel

1. Manufactured by _____^①
 (Name and address of manufacturer of boiler pressure vessel)

2. Manufactured for _____^②
 (Name and address of purchaser)

3. Location of Installation _____^③
 (Name and address)

4. Type _____^④ Boiler No. _____^⑤ _____^⑤
 (resistance element, electrode) (Mfr's. Serial No.) (CRN)
 _____^⑤ _____^⑤ Year Built _____^⑥
 (Drawing No.) (Nat'l. Brd. No.)

5. The chemical and physical properties of all parts meet the requirements of Material Specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to Section I of the ASME Boiler and Pressure Vessel Code _____^⑦.
 Addenda to _____^⑧, and Code Cases _____^⑧ (year)
 (date) (Numbers)

Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors are attached for the following items of this report:
 _____^⑨

 (Name of part, item number, mfr's. name and identifying stamp)

6. Shells or drums: _____^⑩ _____^⑪
 (no.) (mat'l. spec. gr.) [thickness (in.)] [dia (ID)] (length, inside) [dia (ID)] (length, inside)

7. Joints: _____^⑫ _____^⑬ _____^⑭
 [long (seamless, welded)] [efficiency (as compared to seamless)] [girth (seamless, welded)] (no. of shell courses)

8. Heads _____
 (Mat'l. Spec. No.: thickness — flat, dished, ellipsoidal — radius of dish)

9. Other Parts. 1. _____^⑮ 2. _____^⑮ 3. _____^⑮
 (Brief description — i.e., dome, boiler piping, etc.)
 1. _____^⑯ _____^⑰
 2. _____
 3. _____

10. Openings: (a) Steam _____^⑱ (b) Safety Valve _____
 (No., size, and type) (No., size, and type)
 (c) Blowoff _____ (d) Feed _____
 (No., size, and type) (No., size, type, and location)
 (e) Manholes: No. _____ Size _____ Location _____
 (f) Handholes: No. _____ Size _____ Location _____
 (g) Elements/Electrodes: No. _____ Size _____ Location _____

11. Boiler Supports: No. _____ Type _____
 (saddles, legs, lugs)
 Attachment _____
 (bolted or welded)

12. MAWP _____^⑲ psi Based on _____^⑳
 (Code para. and/or formula)

13. Shop Hydrostatic Test _____^㉒ psig 14. Maximum Designed Steaming Capacity _____ lb/hr

15. Remarks _____

㉓ CERTIFICATE OF COMPLIANCE OF BOILER PRESSURE VESSEL

We certify the statements in Part I of this Data Report to be Correct.

Our Certificate of Authorization No. _____^㉔ to use the (S) or (M) _____^㉔

Symbol expires _____^㉔

Date _____ Signed _____ Name _____
 (Authorized Representative) (mfr. of boiler pressure vessel)

This form (E00120) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

25 CERTIFICATE OF SHOP INSPECTION OF BOILER PRESSURE VESSEL

BOILER PRESSURE VESSEL MADE BY _____ at _____
 I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ 26 and employed by _____
 _____ have inspected parts of this boiler pressure vessel referred to as data items _____ 27
 and have examined Manufacturer's Partial Data Reports for Items _____ 28
 and state that, to the best of my knowledge and belief, the manufacturer has constructed this boiler pressure vessel in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE.
 By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.
 Date _____
 _____ Commissions _____ 29
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

Part II—To Be Completed by the Manufacturer Responsible for the Completed Boiler

16.

Item	Piping 30				Valves 31			
	Size	Sch.	Spec.	Bolted, Threaded, or Welded	Size	Type	Rating	No.
(a) Steam Pipe								
(b) Feed Water					Stop			
Feed Water					Check			
(c) Blowoff								

17. Safety Valves(s) No. _____ Size _____ Set Press _____ Total Capacity lb/hr _____
 18. Heating Elements Installed: Quantity _____ kW Total _____
 19. Electrodes: Quantity _____ kW Total _____
 20. Hydrostatic Test of Completed Boiler _____ psig

32 CERTIFICATE OF COMPLIANCE OF COMPLETED BOILER

We certify that this completed boiler conforms with the requirements of SECTION I of the ASME BOILER AND PRESSURE VESSEL CODE.
 Our Certificate of Authorization No. _____ 24 to use the (S), (M), or (E) _____ 24
 Symbol expires _____ 24
 Date _____ Signed _____ By _____
 (Authorized Representative) (Assembler)

CERTIFICATE OF SHOP INSPECTION OF COMPLETED BOILER

BOILER MADE BY _____ at _____
 I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ 26 and employed by _____
 _____ and have inspected the completed boiler and have examined Manufacturer's Partial Data Reports for _____ 34
 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this boiler in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE.
 By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.
 Date _____
 _____ Commissions _____ 29
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

A-351.1 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT, FORM P-2A (See PG-112.2.1.1)

- ① Name and address of Manufacturer, i.e., maker of all components not covered by Partial Data Reports. When the boiler pressure vessel is constructed by a "U" symbol holder and certified on a U-1 or U-1A Data Report, indicate on line 1 "Boiler pressure vessel constructed to Section VIII, Division 1, as permitted by Part PEB," and attach the U-1 or U-1A Data Report.
- ② Name and address of purchaser and/or owner (to be completed by the Manufacturer of the completed boiler).
- ③ Name and address of location where boiler is to be installed. If not known, so indicate (e.g., "Not known—built for stock") (to be completed by the Manufacturer of the completed boiler).
- ④ Show type of electric boiler documented by this Data Report.
- ⑤ Identification of boiler by applicable numbers. If intended for installation in Canada, indicate the Canadian Design Registration Number and drawing number.
- ⑤a The Manufacturer of the boiler pressure vessel shall apply the ASME Code symbol stamp and the National Board Number when required. It is his responsibility to complete Part I of the Data Report, and forward it with the vessel to the company who will apply the trim ("E" symbol holder). The Manufacturer responsible for the trim and completed boiler shall complete Part II of the Data Report and if the boiler is to be stamped "National Board," forward the original Data Report to the National Board for registration.
- ⑥ Year in which fabrication was completed in shop.
- ⑦ Date (year) of Section I Edition under which boiler was constructed.
- ⑧ Issue date of most recent Addenda to Section I under which boiler was constructed (e.g., "1990").
- ⑨ To be completed when one or more components comprising the boiler pressure vessel and furnished by others and certified by Partial Data Report(s), Form P-4.
- ⑩ Show quantity and inside dimensions in inches. If more than two shells or drums are used, enter data in Line 9.
- ⑪ Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-285-B"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.
- ⑫ Indicate type of joint(s).
- ⑬ Show joint efficiency for welded joints.
- ⑭ Same as ⑫ above.
- ⑮ List parts not covered elsewhere on the data report. If insufficient space, attach a supplementary sheet (Form P-6).
- ⑯ Tabulate data for parts listed on Line 9.
- ⑰ Same as ⑪ above.
- ⑱ Show data for main and auxiliary steam outlets only. Does not apply to small openings for water column, controls, vents, etc.
- ⑲ Maximum allowable working pressure established in accordance with PG-21 or Section I.
- ⑳ Show Section I paragraph which applies to the weakest part of the boiler pressure vessel as established by calculation or deformation test.
- ㉑ Deleted.
- ㉒ Hydrostatic pressure applied in accordance with PG-99 and witnessed by the Authorized Inspector.
- ㉓ To be completed and signed by an authorized representative of the Manufacturer.
- ㉔ Show Manufacturer's ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ㉕ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection.

- ②⑥ To determine what goes in the space, you should be guided by the following:
National Board Stamped Boilers and Pressure Vessels (see Form P-2A Line 4)
 After "and/or State or Province" in the certification blocks—
 If the Inspector has a valid commission for the state or province where the Manufacturer's shop is located, insert the name of the state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.
Boilers and Pressure Vessels Not Stamped National Board
 Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector's signature at the bottom of the block.
- ②⑦ Indicate in this space the data items covered on Form P-2 on Lines 6 through 14.
- ②⑧ Indicate by Line numbers those items furnished by others and for which Partial Data Reports (Form P-4) have been examined.
- ②⑨ The Inspector's National Board commission number must be shown when the boiler is stamped "National Board"; otherwise show only his state or province commission number. (See ②⑥ above.)
- ③⑦ When piping is supplied with the boiler for steam, blowoff, and feedwater, complete this section. When welded piping is supplied by another stamp holder, leave blank, and provide separate Form P-4A.
- ③① Complete this section when valves are furnished with the boiler.
- ③② To be completed and signed by an authorized representative of the organization responsible for assembly of the boiler. Show ASME Certificate of Authorization number, kind of symbol, and date of said authorization. When the boiler pressure vessel is constructed by a "U" symbol holder and certified on a U-1 or U-1A Data Report, the "E" symbol holder shall complete lines 1 through 4 of Part 1.
- ③③ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection. Leave blank where final shop inspection is not required as permitted by PEB-18.1.
- ③④ Indicate in this space if the welded piping is furnished by others and is covered on Form P-4A.

**FORM P-3 MANUFACTURERS' DATA REPORT FOR WATERTUBE BOILERS, SUPERHEATERS,
WATERWALLS, AND ECONOMIZERS**
As Required by the Provisions of the ASME Code Rules, Section I

MASTER DATA REPORT YES ☐
(Check one) NO ☐

1. Manufactured by _____ (1)
(Name and address of manufacturer)

2. Manufactured for _____ (2)
(Name and address of purchaser)

3. Location of Installation _____ (3)
(Name and address)

4. Unit Identification _____ (4) ID Nos. _____ (5) _____ (5) _____ (5) _____ (5) _____ (6)
(Complete boiler, superheater, waterwall, economizer, etc.) (Mfr's. Serial No.) (CRN) (Drawing No.) (Nat'l. Board No.) (Year Built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to Section I of the ASME Boiler and Pressure Vessel Code _____ (7)
(Year)

Addenda to _____ (8), and Code Cases _____ (Numbers)
(Date)

Supporting Manufacturer's Data Reports properly identified and signed by Commissioned Inspectors are attached for the following items of this report:
_____ (9)
(Name of part, item number, mfr's name, and identifying stamp)

6(a) Drums

No.	Inside Diameter, in.	Inside Length ft in.	Shell Plates			Tubesheets		Tube Hole Ligament Efficiency, %	
			Mat'l. Spec. No., Grade	Thickness, in.	Inside Radius, in.	Thickness in.	Inside Radius, in.	Longitudinal	Circumferential
1			(10)	(11)		(12)			
2									
3									

No.	Longitudinal Joints		Circum. Joints		Heads					Hydro- static Test, psi	
	No. & type*	Effi- ciency	No. & type	Effi- ciency	Mat'l. Spec. No., Grade	Thickness, in.		Type**	Radius of Dish		Manholes No. Size
1					(10)	(11)	(12)		(13)		(14)
2											
3											

*Indicate if (1) Seamless; (2) Fusion welded.

**Indicate if (1) Flat; (2) Dished; (3) Ellipsoidal; (4) Hemispherical.

6(b) Boiler Tubes

Diameter	Thickness	Mat'l. Spec. No., Grade
(15)	(16)	(10)

6(c) Headers No. _____ (17) _____ (10) _____ (11) or _____ (12)
(Box or sinuous or round; Mat'l. spec. no.; Thickness)

Heads or Ends _____ (18) _____ (10) _____ (12) Hydro. Test, psi _____ (14)
(Shape; Mat'l. spec. no.; Thickness)

6(d) Staybolts _____ (10)
(Mat'l. spec. no.; Diameter; Size telltale; Net area)

Pitch _____ in. Net Area _____ in.² MAWP _____ psi
(Hor. and Vert.) (Supported by one bolt)

6(e) Mud Drum _____ (19) _____ (20) _____ (10) _____ (11) or _____ (12) Heads or Ends _____ (18) _____ (10) _____ (12) Hydro. Test, psi _____ (14)
(For sect. header boilers. State Size; Shape; Mat'l. spec. no.; Thickness) (Shape; Mat'l. spec. no.; Thickness)

7(a) Waterwall Headers				Heads or Ends			7(b) Waterwall Tubes			
No.	Size and Shape	Material Spec. No.	Thickness, in.	Shape	Thickness, in.	Material Spec. No.	Hydro. Test, psi	Diameter, in.	Thickness, in.	Material Spec. No.
	(19) (20)	(10)	(11) (12)	(18)	(12)	(10)	(14)	(15)	(16)	(10)

8(a) Economizer Headers

8(b) Economizer Tubes

This form (E00069) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

Form P-3 (Back)

9(a) Superheater Headers				Heads or Ends			9(b) Superheater Tubes			
No.	Size and Shape	Material Spec. No.	Thickness, in.	Shape	Thickness, in.	Material Spec. No.	Hydro. Test, psi.	Diameter, in.	Thickness, in.	Material Spec. No.
	(19) (20)	(10)	(11) (12)	(18)	(12)	(10)	(14)	(15)	(16)	(10)

10(a) Other Parts (1) _____ (2) _____ (3) _____ 10(b) Tubes for Other Parts

1										
2										
3										

11 Openings (1) Steam _____ (2) _____ (3) _____ (2) Safety Valve _____ (3) _____
 (No., size, and type of nozzles or outlets) (No., size, and type of nozzles or outlets)
 (3) Blowoff _____ (4) Feed _____
 (No., size, and type of nozzles or outlets) (No., size, type, and location of connections)

12		Maximum Allowable Working Pressure	Code Par. and/or Formula on Which MAWP is Based	Shop Hydro. Test, psi	Heating Surface, sq. ft.	Heating surface to be stamped on drum heads. This heating surface not to be used for determining minimum safety valve capacity.	13 Field Hydro. Test, psi
a	Boiler						
b	Waterwall						
c	Economizer						
d	Superheater						
e	Other Parts						

14. Maximum Designed Steaming Capacity _____ lb/hr

15. Remarks _____

24 CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements made in this data report are correct and that all details of design, material, construction, and workmanship of this boiler conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization No. _____ to use the (S) _____ Symbol expires _____
 Date _____ Signed _____ Name _____
 (Authorized Representative) (Manufacturer)

26 CERTIFICATE OF SHOP INSPECTION

BOILER MADE BY _____ at _____

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the state or province of _____ and employed by _____

_____ have inspected parts of this boiler referred to as data items _____
 _____ and have examined Supporting Manufacturer's Data Reports for items _____
 _____ and state that, to the best of my knowledge and belief, the Manufacturer has

constructed this boiler in accordance with Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

31 CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the field assembly of all parts of this boiler conforms with the requirements of SECTION I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization No. _____ to use the (A) or (S) _____ Symbol expires _____
 Date _____ Signed _____ Name _____
 (Authorized Representative) (Assembler)



Form P-3 (Back Cont'd)

33 CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the state or province of _____²⁷ and employed by _____
 _____³⁴ have compared statements in this Manufacturer's Data Report with the described boiler and state that the parts referred to as data items _____³⁴, not included in the Certificate of Shop Inspection, have been inspected by me and that to the best of my knowledge and belief the Manufacturer and/or the assembler has constructed and assembled this boiler in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE. The described boiler was inspected and subjected to a hydrostatic test of _____ psi. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____³⁰
 (Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

A-352 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT, FORM P-3 (See PG-112.2.2)

- ① Name and address of Manufacturer, i.e., maker of all components not covered by Supporting Data Reports.
- ② Name and address of purchaser and/or owner.
- ③ Name and address of location where boiler is to be installed. If not known, so indicate (e.g., "Not known—built for stock").
- ④ Name the unit documented by this Data Report. Note that this report may cover a complete boiler unit or separate component items (e.g., superheaters and economizers) fabricated by a manufacturer other than the Manufacturer of the boiler unit.
- ⑤ Identification of boiler by applicable numbers. If intended for installation in Canada, indicate the Canadian Design Registration Number and drawing number.
- ⑥ Year in which fabrication was completed in shop.
- ⑦ Date (year) of Section I Edition under which boiler was constructed.
- ⑧ Issue date of Addenda to Section I under which boiler was constructed (e.g., "1990").
- ⑨ To be completed when one or more components comprising the boiler are furnished by others, and supported by Data Reports such as Forms P-3, P-4, and P-4a, as appropriate.
- ⑩ Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-285-B"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.
- ⑪ Nominal thickness of the plate.
- ⑫ Minimum thickness after forming.
- ⑬ Radius on concave side of dish.
- ⑭ Shop hydrostatic test, if any, applied to individual part prior to test applied to the assembled boiler (see Lines 12 and 13).
- ⑮ Outside diameter
- ⑯ Minimum thickness of tubes.
- ⑰ This space for headers not covered on Lines 7(a) through 10(a). It is intended primarily for sectional headers on straight tube watertube boilers.
- ⑱ Indicate shape as flat, dished, ellipsoidal, or hemispherical.
- ⑲ Use inside dimensions for size.
- ⑳ Indicate shape as square, round, etc.
- ㉑ Show data for main, auxiliary steam outlets, and feedline connections only. Does not apply to small openings for water columns, controls, vents, drains, instrumentation, or to openings for connections internal to the boiler such as risers, downtakes, or downcomers.
- ㉒ Size is nominal pipe size.
- ㉓ Describe type as flanged, welding neck, etc.
- ㉔ To be completed and signed by an authorized representative of the Manufacturer.
- ㉕ Show Manufacturer's ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ㉖ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection.
- ㉗ To determine what goes in the space, you should be guided by the following:

National Board Stamped Boilers and Pressure Vessels (see Form P-3 Line 4)

After "and/or State or Province" in the certification blocks—

If the Inspector has a valid commission for the state or province where the Manufacturer's shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.

Boilers and Pressure Vessels Not Stamped National Board

Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector's signature at the bottom of the block.

- ②8 Indicate the Data Items covered on Form P-3 on Lines 6 through 14.
- ②9 Indicate by Line numbers those items furnished by others for which Supporting Data Reports have been examined.
- ③0 The Inspector's National Board commission number must be shown when the boiler is stamped National Board; otherwise show only his state or province commission number. (See ②7 above.)
- ③1 To be completed, when applicable, and signed by an authorized representative of the organization responsible for field assembly of the boiler.
- ③2 Show ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ③3 This certificate to be completed by the Authorized Inspection Agency representative who performs the field assembly inspection.
- ③4 Indicate those items on Line 6 through 14 of Form P-3 inspected in the field that were not inspected in the shop.
- ③5 List parts not covered elsewhere on the Data Report. If insufficient space, attach a supplementary sheet (Form P-6).

**FORM P-3A ENGINEERING-CONTRACTOR DATA REPORT FOR A COMPLETE BOILER UNIT
As Required by the Provisions of the ASME Code Rules, Section I**

1. Engineering-Contractor _____^①
(Name and Address)
2. Purchaser _____^②
(Name and Address)
3. Type of Boiler _____^③
4. Boiler Number _____^④ _____^④ _____^④ _____^④ _____^④
(Engineer-Contractor's Serial No.) (CRN) (Drawing No.) (Nat'l. Board No.) (Year Built)
5. The design of this boiler complies with Section I of THE ASME BOILER AND PRESSURE VESSEL CODE _____^⑤, Addenda to
_____^⑥, and Code Cases _____^⑦.
(Date) (Numbers)
6. Design specification for complete boiler unit--list components with their pressure and temperature (use separate sheet if necessary). _____

7. Maximum Designed Steaming Capacity _____ lb/hr

⑧ CERTIFICATE OF COMPLIANCE

We certify the statements in this report to be correct.

Date _____

Signed _____
(Authorized Representative)

Name _____
Engineering Contractor ("S" Stamp holder)

Certificate of Authorization No. _____ Expires _____

⑨ CERTIFICATION OF ENGINEERING-CONTRACTOR

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____^⑩ and employed by _____ of _____ have examined the design specification as described in Item 6 and state that, to the best of my knowledge and belief, the Engineering-Contractor has provided for the construction of a complete boiler unit in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this certification.

Date _____

_____ Commissions _____^⑪
(Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

This form (E00070) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.



Form P-3A (Back)

⑫ CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the field assembly construction of all parts of this boiler conforms with the requirements of SECTION I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization No. _____ ⑬ to use the (A) or (S) _____ ⑬ Symbol expires _____

Date _____ Signed _____ ⑫ Name _____
(Authorized Representative) (Assembler)

⑭ CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the state or province of _____ ⑩ and employed by _____

of _____
have compared statements in this Manufacturer's Data Report with the described boiler and state that the parts referred to as data items _____ ⑮, not included in the Certificate of Shop Inspection, have been inspected by me and that to the best of my knowledge and belief the Manufacturer and/or the assembler has constructed and assembled this boiler in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE. The described boiler was inspected and subjected to a hydrostatic test of _____ psi.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the boiler described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____

_____ Commissions _____ ⑬
(Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

A-353 GUIDE FOR COMPLETING ENGINEERING-CONTRACTOR DATA REPORT FOR A COMPLETE BOILER UNIT, FORM P-3A (See PG-112.2.3)

- ① Name and address of Engineering-Contractor who has assumed the Manufacturer's Code responsibility for the design specifications of the complete boiler unit.
- ② Name and address of purchaser and/or owner.
- ③ Show type of boiler documented by this report (e.g., "Steam watertube with superheat and reheat elements").
- ④ Identification of boiler by applicable numbers and year of manufacture.
- ⑤ Date (year) of Section I Edition to which boiler was designed.
- ⑥ Issue date of Addenda to which boiler was designed (e.g., "1990").
- ⑦ List design specification of the boiler unit in this space [e.g., "Boiler rating—200,000 lb/hr.; Economizer and steam generating section (drums, headers, and tubes)—1,500 psi, 600°F; Superheater elements (headers and tubes)—1,500 psi, 950°F; Reheater elements (headers and tubes)—1,000 psi, 900°F].
- ⑧ To be completed and signed by an authorized representative of the Engineering-Contractor named in 1.
- ⑨ This certificate to be completed by an Authorized Inspection Agency representative.
- ⑩ To determine what goes in the space, you should be guided by the following:
National Board Stamped Boilers and Pressure Vessels (see Form P-3A Line 4)
 After "and/or State or Province" in the certification blocks—
 If the Inspector has a valid commission for the state or province where the Manufacturer's shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.
Boilers and Pressure Vessels Not Stamped National Board
 Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector's signature at the bottom of the block.
- ⑪ The Inspector's National Board commission number should be shown when the boiler is stamped National Board; otherwise show only his state or province commission number. (See ⑩ above.)
- ⑫ To be completed, when applicable, and signed by an authorized representative of the organization responsible to field assembly of the boiler.
- ⑬ Show ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.
- ⑭ This certificate to be completed by the Authorized Inspection Agency representative who performs the field assembly inspection.
- ⑮ Indicate items inspected in the field that were not inspected in the shop. List items on back of Form P-3A or attach appropriate Data Form.

FORM P-4 MANUFACTURERS' PARTIAL DATA REPORT
As Required by the Provisions of the ASME Code Rules, Section I

1. Manufactured by _____ (1) _____, P-4 ID No. _____ (32)
 (Name and address of manufacturer)

2. Manufactured for _____ (2) _____
 (Name and address of purchaser)

3. Identification of Part(s) (3)

Name of Part	Quantity	Line No.	Mfr's. Identifying Numbers	Manufacturers' Drawing No.	CRN	National Board No.	Year Built
(4)		(5)	(6)	(7)		(8)	(9)

4. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design (as indicated on line 14, Remarks), construction, and workmanship conform to ASME Rules, Section I of ASME Boiler and Pressure Vessel Code.

(10) _____, Addenda to _____ (11) _____, and Code Cases _____
 (year) (Date) (Numbers)

6(a). Drums

No.	Inside Diameter, in.	Inside Length ft in.	Shell Plates			Tubesheets		Tube Hole Ligament Efficiency, %	
			Mat'l. Spec. No., Grade	Thickness, in.	Inside Radius, in.	Thickness, in.	Inside Radius, in.	Longitudinal	Circumferential
1			(12)	(13)		(13)		(33)	(33)
2									
3									
4									

No.	Longitudinal Joints		Circum. Joints		Heads						Hydrostatic Test, psi
	No. & Type*	Efficiency	No. & Type	Efficiency	Mat'l. Spec. No., Grade	Thickness, in.		Type**	Radius of Dish	Manholes No. Size	
1					(12)	(13)	(14)		(15)		(16)
2											
3											
4											

*Indicate if (1) Seamless; (2) Fusion welded.

**Indicate if (1) Flat; (2) Dished; (3) Ellipsoidal; (4) Hemispherical.

6(b). Boiler Tubes

Diameter	Thickness	Mat'l. Spec. No., Grade
(17)		(12)

6(c). Headers No. _____ (19) _____ (12) _____ (13) or _____ (14)
 (Box or sinuous or round; Mat'l. spec. no.; Thickness)

Heads or Ends _____ (22) _____ (12) _____ (14) Hydro. Test, psi _____ (16)
 (Shape; Mat'l. spec. no.; Thickness)

6(d). Staybolts _____ (12) _____
 (Mat'l. spec. no.; Diameter; Size telltale; Net area)

Pitch _____ in. Net Area _____ sq in. MAWP _____ (33) psi
 (Hor. and Vert.) (Supported by one bolt)

6(e). Mud Drum _____ (20) _____ (21) _____ (12) _____ (13) or _____ (14) Heads or Ends _____ (22) _____ (12) _____ (14) Hydro Test, psi _____ (16)
 (For sect. header boilers, state: Size; Shape; Mat'l. spec. no.; Thickness) (Shape; Mat'l. spec. no.; Thickness)

7(a). Waterwall Headers

No.	Size and Shape	Material Spec. No.	Thickness, in.	Heads or Ends			Hydro. Test, psi	Diameter, in.	Thickness, in.	Material Spec. No.
				Shape	Thickness, in.	Material Spec. No.				
	(20) (21)	(12)	(13) (14)	(22)	(14)	(12)	(16)	(17)	(18)	(12)

7(b). Waterwall Tubes

This form (E00071) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

Form P-4 (Back)

8(a). Economizer Headers

				Heads or Ends			8(b). Economizer Tubes			
No.	Size and Shape	Material Spec. No.	Thickness, in.	Shape	Thickness, in.	Material Spec. No.	Hydro. Test, psi	Diameter, in.	Thickness, in.	Material Spec. No.
	(20) (21)	(12)	(13) or (14)	(22)	(14)	(12)	(16)	(17)	(18)	(12)

9(a). Superheater Headers

9(b). Superheater Tubes

10(a). Other Parts (1) _____ (31) _____ (2) _____ (3) _____

1										
2										
3										

10(b). Tubes for Other Parts

11. Openings (1) Steam _____ (23) (24) (25) _____

(No., size, and type of nozzles or outlets)

(2) Safety Valve _____ (24) (25) _____

(No., size, and type of nozzles or outlets)

(3) Blowoff _____ (24) (25) _____

(No., size, and type of nozzles or outlets)

(4) Feed _____ (24) (25) _____

(No., size, type, and location of connections)

12.

		(33) Maximum Allowable Working Pressure	(33) Code Para. and/or Formula on Which MAWP is Based	Shop Hydro. Test, psi	Heating Surface, sq ft		13. Field Hydro. Test, psi
a	Boiler					Heating surface to be stamped on drum heads.	
b	Waterwall						
c	Economizer					This heating surface not to be used for determining minimum safety valve capacity.	
d	Superheater						
e	Other Parts						

14. Remarks: _____ (26) (34) _____

(27)

CERTIFICATE OF SHOP COMPLIANCE

We certify the statements made in this Manufacturers' Partial Data Report to be correct and that all details of design (as indicated on line 14, Remarks), material, construction, and workmanship of this boiler part conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization No. _____ to use the (PP) or (S) _____ Symbol expires _____.

Date _____ Signed _____ Name _____
(Authorized Representative) (Manufacturer)

(28)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ (29) and employed by _____

_____ have inspected the part of a boiler described in this Manufacturers' Partial Data Report on _____, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this part in accordance with the applicable sections of the ASME BOILER AND PRESSURE VESSEL CODE.

By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the part described in this Manufacturers' Partial Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____ (30)
(Authorized Inspector) [Nat'l. Board (incl. endorsements), State, Province, and No.]

A-354 GUIDE FOR COMPLETING MANUFACTURERS' PARTIAL DATA REPORT, FORM P-4 (See PG-112.2.4)

- ① Name and address of manufacturer of the part(s) reported on the Form P-4.
- ② Name and address of Manufacturer of the boiler unit with which the part(s) will be used, if known. If built for stock, so state. If for an existing unit, name of the owner or user and address of the unit at place of installation.
- ③ Identification of individual parts documented by the Form P-4.
- ④ Show name of part, e.g., "steam drum," "Superheater header," etc.
- ⑤ Show data Line number of Form P-4 for the named part.
- ⑥ Show manufacturer's serial or other numbers stamped on the named part.
- ⑦ Show the drawing number for the named part.
- ⑧ Where applicable, the National Board Number from the Manufacturer's series of National Board Numbers.
- ⑨ Year in which fabrication of the part was completed in the shop.
- ⑩ Date (year) of Section I Edition under which part was constructed.
- ⑪ Issue date of Addenda to Section I under which part was constructed (e.g., "1990").
- ⑫ Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-285-B"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case Number shall be shown.
- ⑬ Nominal thickness of the plate.
- ⑭ Minimum thickness after forming.
- ⑮ Radius on concave side of dish.
- ⑯ Shop hydrostatic test, if any, applied to individual part prior to test applied to the assembled boiler (see Lines 12 and 13).
- ⑰ Outside diameter.
- ⑱ Minimum thickness of tubes.
- ⑲ This space for headers not covered in Lines 7(a) through 10(a). It is intended primarily for sectional headers on straight tube watertube boilers.
- ⑳ Use inside dimensions for size.
- ㉑ Indicate shape as square, round, etc.
- ㉒ Indicate shape as flat, dished, ellipsoidal, or hemispherical.
- ㉓ Show data for main, auxiliary steam outlets, and feedline connections only. Does not apply to small openings for water columns, controls, vents, drains, instrumentation, or to openings for connections internal to the boiler such as risers, downtakes, or downcomers.
- ㉔ Size is nominal pipe size.
- ㉕ Describe type as flanged, welding neck, etc.
- ㉖ Any additional information to clarify the report should be entered here. When applicable and when it is known, indicate the National Board Number of the completed boiler.
- ㉗ To be completed and signed by an authorized representative of the part(s) manufacturer.
- ㉘ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection. If a National Board Number has been assigned to the part, the inspector signing this certificate must hold a valid National Board Commission.
- ㉙ To determine what goes in the space, you should be guided by the following:

National Board Stamped Boiler and Pressure Vessel Parts (see Form P-4 Line 3)
After "and/or State or Province" in the certification blocks—

If the Inspector has a valid commission for the state or province where the manufacturer's shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.

Boiler and Pressure Vessel Parts Not Stamped National Board

Follow the above procedure. However, in this case, do not list any National Board Commission number after the Inspector's signature at the bottom of the block.

- ③① The Inspector's National Board commission number should be shown if it is known that the part is to be used on a completed boiler that is to be stamped National Board or if a National Board Number has been assigned to the part; otherwise show only his state or province number. (See ②⑨ above.)
- ③② List parts not covered elsewhere on the Data Report. If insufficient space, attach a supplementary sheet (Form P-6).
- ③③ If desired, the Certificate Holder may assign a unique identifying number for this form.
- ③④ Indicate data, if known.
- ③⑤ Indicate extent of design function [See PG-112.2.4(3)].

01

FORM P-4A MANUFACTURERS' DATA REPORT FOR FABRICATED PIPING
As Required by the Provisions of the ASME Code Rules, Section I

1. Manufactured by _____⁽¹⁾ Order No. _____⁽¹⁾ P-4A ID No. _____⁽²³⁾
(Name and address of manufacturer)
2. Manufactured for _____⁽²⁾ Order No. _____⁽²⁾
(Name and address of purchaser)
3. Location of Installation _____⁽³⁾ Boiler Registration No. _____^(3a)
4. Identification _____⁽⁴⁾ Piping Registration No. _____^(4a)
(Main steam, boiler feed, blow-off or other service piping — state which)
5. Design Conditions of Piping _____⁽⁵⁾ psi _____⁽⁵⁾ F. Specified by _____⁽⁶⁾
(Pressure) (Temperature) (Name of Co.)
- Code Design by _____⁽⁷⁾
6. The chemical and physical properties of all piping meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The construction and workmanship conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE _____^(Year)
- Addenda to _____⁽⁸⁾, and Code Cases _____^(Numbers)
(Date)
7. Description of Piping: (include materials Identifications by ASME specification or other recognized Code designation.)
(9)
8. Shop Hydrostatic Test _____⁽¹⁰⁾ psi.
9. Remarks _____

CERTIFICATE OF SHOP COMPLIANCE

We certify the statement in this data report to be correct and that all details of material, construction, and workmanship of the described piping conform to Section I of the ASME Boiler and Pressure Vessel Code.

Our Certificate of Authorization No. _____⁽¹²⁾ to use the S or PP Symbol _____⁽¹²⁾ Expires _____⁽¹²⁾

Date _____⁽¹¹⁾ Signed _____⁽¹¹⁾ by _____⁽¹¹⁾
(Manufacturer or Fabricator) (Authorized Representative)

⁽¹³⁾ CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____⁽¹⁴⁾ and employed by _____ have inspected the piping described in this Manufacturer's Data Report and state that to the best of my knowledge and belief, the manufacturer has constructed this piping in accordance with the applicable Sections of the ASME Boiler and Pressure Vessel Code.

By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the piping described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____

(Authorized Inspector) Commissions _____⁽¹⁵⁾
[Nat'l Board (incl. endorsements), State, Province, and No.]

This form (E00072) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

FORM P-4A (Back)

10. Description of Field Fabrication:

(16)

11. Field Hydrostatic Test _____ (17) _____ psi.

(18)

CERTIFICATE OF FIELD FABRICATION COMPLIANCE

We certify the statement in this data report to be correct and that all details of material, construction, and workmanship of the described piping conform to Section I of the ASME Boiler and Pressure Vessel Code.

Our Certificate of Authorization No. _____ (19) _____ to use the Pressure Piping Symbol expires _____ (19) _____.

Date _____ (18) _____ Signed _____ (18) _____ Name _____ (18) _____
 (Authorized Representative) (Fabricator)

(18)

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the field assembly of the described piping conforms with the requirements of Section I of the ASME Boiler and Pressure Vessel Code. Our Certificate of Authorization No. _____ (19) _____ to use the (A) (S) or (PP) Symbol expires _____ (19) _____.

Date _____ (18) _____ Signed _____ (18) _____ Name _____ (18) _____
 (Authorized Representative) (Assembler)

(20)

CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ (14) _____ and employed by _____

have compared the statements in this Manufacturer's Data Report with the described piping and state that the parts referred to as Data Items _____ (21) _____, not included in the Certificate of Shop Inspection, have been inspected by me and that to the best of my knowledge and belief the manufacturer and/or assembler has constructed and assembled this piping in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code. The described piping was inspected and subjected to a hydrostatic test of _____ (22) _____ psi.

By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the piping described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____

 (Authorized Inspector) Commissions _____ (15) _____
 [Nat'l Board (incl. endorsements), State, Province, and No.]

01 A-354.1 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT, FORM P-4A (See PG-112.2.5)

- ① Name and address of manufacturer or fabricator of Code piping including order identifying number.
- ② Name and address of purchaser and/or owner and his identifying order number.
- ③ Name and address of location where piping is to be installed, if known.
- ③a Include the registration number of the boiler where the piping is to be installed, if known (e.g., National Board No., Canadian Design Registration No., or other jurisdictionally required registration numbers).
- ④ Identify each section of piping (e.g., main steam, blow-off, boiler feed), including the section's identification number, if assigned.
- ④a Include the piping registration number, if assigned (e.g., National Board No., Canadian Design Registration No., or other jurisdictionally required registration numbers).
- ⑤ Show the maximum design pressure and temperature of the section of pipe (see ASME B31.1).
- ⑥ Name of the organization that established the design pressure and temperature.
- ⑦ The organization that made the calculations and selected the pipe schedules for the working conditions.
- ⑧ Refer to the requirements of ASME B31.1.
- ⑨ Describe each section of piping, size, thickness, schedule, etc. Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-106"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown. Identify the organization that will receive this piping and the identification number of the boiler.
- ⑩ Piping fabricated in a shop show test pressure if hydro-applied in the shop (see PG-99) and witnessed by Authorized Inspector.
- ⑪ The name of the piping manufacturer or fabricator, signature of authorized representative and date signed.
- ⑫ Show ASME Authorization number, kind of symbol, and date of expiration.
- ⑬ This certificate to be completed by the Authorized Inspection Agency representative who performs the in-shop inspection.
- ⑭ To determine what goes in this space, you should be guided by the following:
National Board Stamped Fabricated Piping (see Form P-4A Line 4)
 After "and/or State or Province" in the certification blocks—
 If the Inspector has a valid commission for the state or province where the Manufacturer's shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.
Fabricated Piping Not Stamped National Board
 Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector's signature at the bottom of the block.
- ⑮ The Inspector's National Board commission number must be shown when the fabricated piping is stamped National Board; otherwise, show only his/her state or province commission number (See 14 above).
- ⑯ Describe sections of piping to be joined, design of welded joint, procedure to be followed, number passes, preheat, postheat, etc. (see ASME B31.1).
- ⑰ Show test pressure used during field hydrostatic test (see PG-99) and witnessed by the Authorized Inspector.
- ⑱ Signed by an authorized representative of the organization responsible for the field fabrication or field assembly (assembler, manufacturer, fabricator), or both, and the date signed.
- ⑲ Show ASME authorization number, kind of symbol, and date of expiration.
- ⑳ This certificate to be completed by the Authorized Inspection Agency representative who performs the field assembly inspection.
- ㉑ Only list those piping sections and welds inspected in the field.
- ㉒ Show field hydrostatic test pressure (see PG-99).
- ㉓ If desired, the Certificate Holder may assign a unique identifying number for this Form.

FORM P-4B MANUFACTURER'S DATA REPORT FOR FIELD INSTALLED MECHANICALLY ASSEMBLED PIPING
As Required by the Provisions of the ASME Code Rules, Section I

1. Manufactured by _____ (1) _____ Order No. _____ (1) _____ P-4B ID No. _____ (17)
(Name and address of manufacturer)

2. Manufactured for _____ (2) _____ Order No. _____ (2) _____
(Name and address of purchaser)

3. Location of Installation _____ (3) _____ Boiler Registration No. _____ (3a)

4. Identification _____ (4) _____ Piping Registration No. _____ (4a)
(Main steam, boiler feed, blow-off or other service piping — state which)

5. Design Conditions of Piping _____ (5) _____ psi _____ (5) _____ °F. Specified by _____ (6) _____
(Pressure) (Temperature) (Name of Co.)

Code Design by _____ (7)

6. The chemical and physical properties of all piping meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The construction and workmanship conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE _____ (Year),
 Addenda to _____ (Date), and Code Cases _____ (8) _____ (Numbers)

7. Description of Piping: (Include materials identifications by ASME specification or other recognized Code designation.)
 _____ (9)

8. Field Hydrostatic Test _____ (10) _____ psi.

9. Remarks _____

(11) CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the field assembly of the described piping conforms with the requirements of Section I of the ASME Boiler and Pressure Vessel Code. Our Certificate of Authorization No. _____ (12) _____ to use the (A) (S) or (PP) Symbol expires _____ (12) _____.

Date _____ (12) _____ Signed _____ (Authorized Representative) Name _____ (Assembler)

(13) CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ (14) _____ and employed by _____ have compared the statements in this Manufacturer's Data Report with the described piping and state that the parts referred to as Data Items _____ (15) _____ have been inspected by me and that to the best of my knowledge and belief the manufacturer and/or assembler has assembled this piping in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code. The described piping was inspected and subjected to a hydrostatic test of _____ (16) _____ psi.

By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the piping described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date _____

(Authorized inspector) Commissions _____ (17) _____
[Nat'l Board (incl. endorsements), State, Province, and No.]

This form (E00133) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.



01 **A-354.2 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT, FORM P-4B (See PG-112.2.5)**

- ① Name and address of manufacturer or fabricator of Code piping including order identifying number.
- ② Name and address of purchaser and/or owner and his identifying order number.
- ③ Name and address of location where piping is to be installed, if known.
- ③a Include the registration number of the boiler where the piping is to be installed, if known (e.g., National Board No., Canadian Design Registration No., or other jurisdictionally required registration numbers).
- ④ Identify each section of piping (e.g., main steam, blow-off, boiler feed), including the section's identification number, if assigned.
- ④a Include the piping registration number, if assigned (e.g., National Board No., Canadian Design Registration No., or other jurisdictionally required registration numbers).
- ⑤ Show the maximum design pressure and temperature of the section of pipe (see ASME B31.1).
- ⑥ Name of the organization that established the design pressure and temperature.
- ⑦ The organization that made the calculations and selected the pipe schedules for the working conditions.
- ⑧ Refer to the requirements of ASME B31.1.
- ⑨ Describe each section of piping, size, thickness, schedule, etc. Show the complete ASME Material Specification No. and Grade as listed in the appropriate stress allowance table in the Appendix of Section I (e.g., "SA-106"). Exception: A specification number for a material not identical to an ASME Specification may be shown *only* if such material meets the criteria in the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.
- ⑩ Piping fabricated in field show test pressure of hydro-applied in the field (see PG-99) and witnessed by Authorized Inspector.
- ⑪ Signed by an authorized representative of the organization responsible for the field assembly and hydrostatic test.
- ⑫ Show ASME authorization number, kind of symbol, and date of expiration.
- ⑬ This certificate to be completed by the Authorized Inspection Agency representative who performs the field assembly inspection.
- ⑭ To determine what goes in this space, you should be guided by the following:
National Board Stamped Fabricated Piping (see Form P-4B Line 4)
 After "and/or State or Province" in the certification blocks—
 If the Inspector has a valid commission for the state or province where the Manufacturer's shop is located, insert the name of that state or province. If the Manufacturer is located in a non-Code state or province, insert the name of the state or province where the Inspector took his original examination to obtain his National Board Commission, provided he still has a valid commission for that state or province. Otherwise, if no valid commission, show the name of the state or province where he has a valid commission authorizing him to make the shop inspection.
Fabricated Piping Not Stamped National Board
 Follow the above procedure. However, in this case do not list any National Board Commission number after the Inspector's signature at the bottom of the block.
- ⑮ Only list those piping sections inspected in the field.
- ⑯ Show test pressure used during field hydrostatic test (see PG-99) and witnessed by the Authorized Inspector.
- ⑰ The Inspector's National Board commission number must be shown when the fabricated piping is stamped National Board; otherwise, show only his state or province commission number.
- ⑱ If desired, the Certificate Holder may assign a unique identifying number for this Form.

FORM P-5 SUMMARY DATA REPORT FOR PROCESS STEAM GENERATORS
As Required by the Provisions of the ASME Code Rules, Section I

1. Manufacturer (or Engineering-Contractor) _____^①
 (Name and Address)
2. Purchaser _____^②
 (Name and Address)
3. Location of Installation _____^③
 (Name and Address)
4. Type of Boiler _____^④
5. Boiler No. _____
 (Mfr's. Serial) (CRN) (Drawing No.) (Nat'l. Brd. No.) (Year Built)
6. Data Reports Attached _____^⑤

No.	Name of Part	Part Manufacturer	Identifying Numbers	Data Report Form
1	⑥	⑦	⑧	⑨
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

7. Remarks _____

⑩ CERTIFICATE OF COMPLIANCE

We certify the statements of this Summary Data Report, with the attached certified data reports as listed, provide documentation that the design, construction, materials, and workmanship of the complete boiler unit do conform to the ASME Rules, Section I of the ASME Boiler and Pressure Vessel Code _____^⑪, Addenda to _____^⑫, and Code Cases _____
 (Year) (Date) (Numbers)

Our Certificate of Authorization No. _____ to use the "S" Symbol expires _____.

Signed _____ Name _____
 (Authorized Representative) (Mfr. or Eng. Contractor)

This form (E00073) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

A-355 GUIDE FOR COMPLETING SUMMARY DATA REPORT FOR PROCESS STEAM GENERATORS, FORM P-5 (See PG-112.2.6)

- ① Name and address of the Manufacturer or Engineering-Contractor, whichever is responsible for the complete boiler installation.
- ② Name and address of the purchaser and/or owner.
- ③ Name and address of location where boiler is installed.
- ④ Indicate type of boiler (e.g., "Steam Watertube — Drum Type").
- ⑤ In this section list all parts covered by the various Data Report Forms, P-2, P-3, P-3A, P-4 or P-4A. Use supplementary sheet (Form P-6) if necessary. A copy of each Data Form shall be securely attached to Form P-5.
- ⑥ Show name of part, e.g., "Steam Drum," "Waterwall Header," etc.
- ⑦ Name of the manufacturer of the named part.
- ⑧ Show manufacturer's serial number and other numbers stamped on the named part.
- ⑨ List Manufacturer's Data Report Form number (e.g., "P-4").
- ⑩ To be completed and signed by an authorized representative of the Manufacturer or Engineering-Contractor named in ①.
- ⑪ Date (year) of Section I Edition under which boiler was constructed.
- ⑫ Issue date of most recent Addenda to Section I under which boiler was constructed (e.g., "Summer 1972").

1. Manufacturer (or Engineering-Contractor) _____
(Name and Address)

2. Purchaser _____
(Name and Address)

3. Type of Boiler _____

4. Boiler No. _____
(Mfr's. Serial No.) (CRN) (Drawing No.) (Nat'l Board No.)

_____ (Year Built)

[illegible]

Date _____ Signed _____ by _____

Date _____

Commissions	
(Authorized Inspector)	[Nat'l Board (incl. endorsements), State, Province, and No.]

This form (E00074) may be obtained from the ASME Order Dept., 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

1. Boiler manufactured by _____, P-7 ID No. _____
(Name and address of Manufacturer)

2. Boiler manufactured for _____
(Name and address of purchaser)

3. Location of installation _____
(Name and address)

4. Unit identification _____ ID Nos. _____
(Complete boiler, superheater, waterwall, economizer, etc.)

(Mfr's. Serial No.) (CRN) (Drawing No.) (Nat'l. Board No.)

[illegible]

** Connector type: (A) Groove Weld. (B) Socket Weld. (C) Threaded. (D) Flanged.

Circuit	Minimum Required (lb/hr) ⁽¹⁶⁾	Furnished (lb/hr) ⁽¹⁷⁾
Boiler		
Economizer		
Superheater		
Reheater Inlet		
Reheater Outlet		
Other		

FORM P-7 (Back)

⑮ CERTIFICATE OF COMPLIANCE

We certify the statements in this Manufacturers' Data Report for Safety Valves to be correct and that all details conform to Section I of the ASME BOILER AND PRESSURE VESSEL CODE.

Our Certificate of Authorization No. _____ to use the (S) or (M) _____ Symbol expires _____.

Date _____ Signed _____ (Authorized Representative) Name _____ (Manufacturer)

A-356 GUIDE FOR COMPLETING MANUFACTURERS' DATA REPORT FOR SAFETY VALVES, FORM P-7 (See PG-112.2.8)

- ① Name and address of boiler Manufacturer, i.e., maker of all components not covered by supporting Data Reports or engineering contractor who has assumed the Manufacturer's Code responsibility for the Design Specifications of the complete boiler unit.
- ② If desired, the Certificate Holder may assign a unique identifying number for this form.
- ③ Name and address of purchaser and/or owner.
- ④ Name and address of location where boiler is to be installed. If not known, so indicate (e.g., "Not known" — built for stock).
- ⑤ Name the unit documented by this Data Report.
- ⑥ Identification of boiler by applicable numbers. If intended for installation in Canada, indicate the Canadian Design Registration Number and drawing number.
NOTE: Items ①, ③, ④, ⑤, and ⑥ shall repeat similar information on the Master Data Report.
- ⑦ Optional — List purchaser's or owner's identification number assigned to valve (preferred) or tag number supplied by the Manufacturer.
- ⑧ Valve service location (e.g., "Boiler Drum, Superheater Outlet Header, Main Steam Piping, Cold Reheat Piping, Reheat Outlet Header, etc.").
- ⑨ Quantity of identical valves installed at valve service location.
- ⑩ Valve inlet size.
- ⑪ Valve manufacturer's name.
- ⑫ Valve manufacturer's figure number or other design-type designation number.
- ⑬ Valve body material and connection type.
- ⑭ Pressure at which safety valve is set to relieve.
- ⑮ Certified relieving capacity of the safety valve.
- ⑯ Minimum relieving safety valve relieving capacity, as required by PG-67 and PG-68.
- ⑰ Actual relieving safety valve relieving capacity furnished at locations indicated.
- ⑱ Show Manufacturer's ASME Certificate of Authorization number, kind of symbol, and date of expiration of said authorization.

A-357 GUIDE TO DATA REPORT FORMS DISTRIBUTION
Data Report Forms Required for Section I Construction

Example	Data Report Forms Required								Remarks
	P-2	P-2A	P-3	P-3A	P-4	P-4A	P-4B	P-5	
1	X						X		P-4B is submitted to authorities separately by the stamp holder assuming responsibility for the hydrostatic test.
2	X					X			P-4A is submitted to authorities separately by piping contractor.
3			X		X	X			P-4A is submitted to authorities separately by piping contractor.
4			X			X			P-3 is also Master Data Report.
5			X			X			P-3 is also Master Data Report.
6			X	X	X	X			P-3 or P-4 is required for each manufacturer supplying major component. Assembler completes field assembly portion of P-3A. P-3A submitted by Engineering-Contractor is also Master Data Report.
7			X						P-4A is not required since all work comprising Code responsibility is done by one contractor.
8		X							Appropriate portion of P-2A is completed by manufacturer of boiler pressure vessel. Shop inspection block is completed by boiler pressure vessel manufacturer's Authorized Inspector. Electric boiler Manufacturer completes the balance of P-2A.
9	X		X	X	X	X		X	P-2, P-3, or P-4 is required for each Manufacturer supplying major component. Assembler completes field assembly portion of P-3A. Summary Data Report P-5 submitted by Engineering-Contractor is Master Data Report.

- Example 1 Boiler Manufacturer supplies shop-assembled firetube boiler without piping. Piping contractor, not responsible to boiler Manufacturer, supplies and installs threaded piping.
- Example 2 Boiler Manufacturer supplies shop-assembled firetube boiler without piping. Piping contractor ("PP" stamp holder) not responsible to boiler Manufacturer, supplies and installs welded piping.
- Example 3 Boiler Manufacturer supplies shop-assembled watertube boiler. He subcontracts boiler drums to another manufacturer. External piping (welded) is subcontracted to a piping contractor.
- Example 4 Boiler Manufacturer supplies field-assembled watertube boiler. Field assembly is subcontracted to a contractor ("A" stamp holder) and external piping (welded) is subcontracted to a piping contractor ("PP" stamp holder).
- Example 5 Boiler Manufacturer supplies and erects field-assembled watertube boiler. Owner contracts with piping contractor ("PP" stamp holder) for supply and installation of piping (welded).
- Example 6 Engineering-Contractor designs boiler. Several manufacturers supply component parts, such as boiler drum, tubes, superheater, economizer. In addition, a contractor holding a "PP" stamp supplies headers to superheater manufacturer. A contractor holding an "A" stamp performs the field assembly. A piping contractor supplies and installs boiler piping (welded).
- Example 7 Boiler Manufacturer supplies and installs field-assembled boiler, including boiler piping (welded).
- Example 8 Electric boiler Manufacturer holding an "E" stamp completes assembly of piping and appurtenances (no welding). Boiler pressure vessel manufactured by "S" or "M" stamp holder.
- Example 9 Engineering-Contractor designs a process steam generator consisting of several arrays of heat exchange surface. Several manufacturers supply component parts. A contractor holding an "A" stamp performs field assembly. A piping contractor holding a "PP" stamp supplies and installs boiler piping (welded).

A-370 GUIDE TO INFORMATION APPEARING ON CERTIFICATE OF AUTHORIZATION

ITEM	DESCRIPTION
①	a. The name of the Manufacturer or Assembler; this description could include "doing business as" (DBA) or an abbreviation of the name. b. The full street address or physical location, city, state or province, country, and zip code.
②	This entry describes the scope and limitations, if any, on use of the Code symbol stamps, as illustrated below. "S" Code Symbol Stamp 1. Manufacture and assembly of power boilers at the above location. 2. Manufacture and assembly of power boilers at the above location and field sites controlled by the above location. 3. Design and assembly of power boilers with fabrication subcontracted to holders of appropriate Certificates of Authorization and field assembly at field sites controlled by the above location. 4. Design of power boilers with responsibility for compiling Code certification and for stamping the boiler. Fabrication and assembly subcontracted to holders of appropriate Certificates of Authorization. "A" Code Symbol Stamp 1. Assembly of Power Boilers at field sites controlled by the above location. "PP" Code Symbol Stamp 1. Design, fabrication, and assembly of pressure piping. "M" Code Symbol Stamp 1. Manufacture and assembly of miniature boilers at the above location only. "E" Code Symbol Stamp 1. Design and assembly of electric boilers at the above location only. "V" Code Symbol Stamp 1. Manufacture of safety valves for power boilers at the above location only. 2. Manufacture of safety valves for power boilers at the above location only. (This authorization does not cover welding or brazing.) 3. Assembly of safety valves for power boilers at the above location. (This authorization does not cover welding or brazing.)
③	The date authorization was granted by the Society to use the Code symbol stamp indicated.
④	The date authorization to use the Code symbol stamp will expire.
⑤	A unique Certificate number assigned by the Society.
⑥	Code Symbol granted by the Society, e.g., "S," power boiler; "M," miniature boiler; "E," electric boiler; "A," boiler assembly; "PP," pressure piping; and "V," safety valve.
⑦,⑧	The signatures of the current chairman and director.

CERTIFICATE OF AUTHORIZATION

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the Code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY ①

SCOPE ②

AUTHORIZED ③

EXPIRES ④

CERTIFICATE NUMBER ⑤

SYMBOL ⑥

The American Society of Mechanical Engineers



®

⑦
CHAIRMAN OF THE BOILER
AND PRESSURE VESSEL COMMITTEE

⑧
DIRECTOR, ASME ACCREDITATION AND CERTIFICATION

FIG. A-370 SAMPLE CERTIFICATE OF AUTHORIZATION

A-380 SAMPLE CALCULATIONS FOR EXTERNAL PRESSURE DESIGN

NOTE: In A-381 and A-382, referenced stress tables and external pressure charts are contained in Subparts 1 and 3, respectively, in Section II, Part D.

A-381 A ring reinforced furnace is to be installed in a Scotch Marine type boiler. From the following design data, determine if the furnace is satisfactory for a design pressure of 150 psi (saturated steam temperature 366°F): SA-515 Grade 70 plate $\frac{5}{8}$ in. thick, 36 in. outside diameter, 144 in. between tubesheets, 36 in. greatest distance between adjacent stiffening rings, stiffening rings are attached by full penetration welds, and rings are $\frac{5}{8}$ in. wide and 3 in. high. Show all calculations.

Given: ring reinforced furnace

$$\begin{aligned} P &= 150 \text{ psi} \\ \text{material} &= \text{SA-515, Grade 70} \\ t &= 0.625 \text{ in.} \\ D_o &= 36 \text{ in.} \\ L_s &= 36 \text{ in.} \\ L_s &= \text{the smaller of } 36 \text{ in. or } 60t. \quad 60t = 60(0.625) = 37.5. \text{ Therefore, } L = 36 \text{ in. (see PFT-17.6)} \end{aligned}$$

$$\text{saturated steam temperature} = 366^\circ\text{F}$$

Assume:

$$\begin{aligned} \text{saturated steam temperature} &= \text{water temperature} \\ T_{\text{design}} &= T_{\text{water}} + 100^\circ\text{F} = 366^\circ\text{F} + 100^\circ\text{F} = 466^\circ\text{F} \\ T_r &= 0.625 \text{ in.} \\ H_r &= 3 \text{ in.} \end{aligned}$$

Find: Does this design meet Section I requirements?

Use: PFT-17 and PFT-51

Solve: Per PFT-51.1.2(a), determine if $D_o/t \geq 10$.

Calculate D_o/t

where

$$\begin{aligned} D_o &= 36 \text{ in. (given)} \\ t &= 0.625 \text{ in. (given)} \\ D_o/t &= 36/0.625 = 57.6 \end{aligned}$$

Since D_o/t is greater than 10, follow the procedure outlined in PFT-51.1.2(a).

Step 1: Determine the ratio of L/D_o and D_o/t . Calculate L/D_o

where

$$\begin{aligned} L &= 36 \text{ in. (given)} \\ D_o &= 36 \text{ in. (given)} \\ L/D_o &= 36/36 = 1 \end{aligned}$$

Calculate D_o/t

where

$$\begin{aligned} D_o &= 36 \text{ in. (given)} \\ t &= 0.625 \text{ in. (given)} \\ D_o/t &= 36/0.625 = 57.6 \end{aligned}$$

Step 2: Enter Fig. G of Section II, Part D, the value of $L/D_o = 1$

Step 3: Enter Fig. G of Section II, Part D, the value of $D_o/t = 57.6$

Find Factor A.

$$\text{Factor A} = 0.0031$$

Step 4: Enter Table 1A of Section II, Part D, for SA-515, Grade 70, at 466°F. The external pressure chart to be used is Fig. CS-2 of Section II, Part D. Enter Fig. CS-2 of Section II, Part D, and find the intersection of 0.0031 and 466°F.

Step 5: Find Factor B.

$$\text{Factor B} = 13,500$$

Step 6: Calculate MAWP

$$P = \frac{4(B)}{3(D_o/t)}$$

where

$$\begin{aligned} B &= 13,500 \text{ (see Fig. CS-2 of Section II, Part D)} \\ D_o &= 36 \text{ in. (given)} \\ t &= 0.625 \text{ in. (given)} \end{aligned}$$

$$P = \frac{4(13,500)}{3(36/0.625)}$$

$$P = 312.50 \text{ psi}$$

The required moment of inertia:

$$I_s = \frac{(36)^2 (36) [0.625 + (1.875/36)] (0.00059)}{14}$$

Step 1: Calculate A_s

$$A_s = (H_r)(T_r)$$

where

$$H_r = 3 \text{ in. (given)}$$

$$T_r = 0.625 \text{ in. (given)}$$

$$A_s = (3)(0.625)$$

$$A_s = 1.875 \text{ sq in.}$$

Calculate B

$$B = \frac{P D_o}{t + (A_s/L_s)}$$

where

$$P = 150 \text{ psi (given)}$$

$$D_o = 36 \text{ in. (given)}$$

$$t = 0.625 \text{ in. (given)}$$

$$A_s = 1.875 \text{ sq in. (calculated)}$$

$$L_s = 36 \text{ in. (given)}$$

$$B = \frac{(150)(36)}{0.625 + (1.875/36)}$$

$$B = 7,975 \text{ psi}$$

Steps 2 and 3: Enter Table 1A of Section II, Part D, for SA-515, Grade 70. The external pressure chart to be used is Fig. CS-2 of Section II, Part D. Enter Fig. CS-2 of Section II, Part D, and find the intersection of 7,975 psi and 466°F.

Step 4: Find Factor A .

$$\text{Factor } A = 0.00059$$

Step 5: Calculate I_s

$$I_s = \frac{(D_o)^2 L_s [t + (A_s/L_s)] A}{14}$$

where

$$D_o = 36 \text{ in. (given)}$$

$$L_s = 36 \text{ in. (given)}$$

$$t = 0.625 \text{ in. (given)}$$

$$A_s = 1.875 \text{ sq in. (calculated)}$$

$$A = 0.00059 \text{ (see Fig. CS-2 of Section II, Part D)}$$

$$I_s = 1.3313 \text{ in.}^4$$

Step 6: Calculate actual moment of inertia I :

$$I = \frac{(T_r)(H_r^3)}{12}$$

where

$$T_r = 0.625 \text{ in. (given)}$$

$$H_r = 3 \text{ in. (given)}$$

$$I = \frac{(0.625)(3)^3}{12}$$

$$I = 1.4062 \text{ in.}^4$$

Step 7: Compare I_s to I .

I_s (1.3313 in.⁴) is less than I (1.4062 in.⁴); therefore, the design of this furnace does meet Section I requirements.

A-382 A combination furnace in a boiler is made up of a Morison central section whose least inside diameter measured across the convex curve of the corrugations is 34½ in., plate thickness is ⅝ in. and length is 8 ft 4 in. The plain-end sections are joined by full-penetration butt welds and measure 18½ in. from weld to head attachment. These sections are 36 in. in inside diameter and have a wall thickness of ¾ in. What is the MAWP of this furnace? Material is SA-285C at 700°F.

Given: combination furnace

Morison Section

$$ID = 34.5 \text{ in.}$$

$$D = \text{least } ID + 2 = 34.5 + 2$$

$$= 36.5 \text{ (see PFT-18.1)}$$

$$t = \frac{5}{8} \text{ in.} = 0.625 \text{ in.}$$

$$L = 100 \text{ in.}$$

Plain Section

$$L = 18.5 \text{ in.}$$

$$2L = 37 \text{ in. (see PFT-19.2)}$$

$$ID = 36 \text{ in.}$$

$$D_o = ID + 2t = 36 + 2(0.75)$$

$$= 37.5 \text{ in.}$$

$$t = 0.75$$

$$\text{material} = \text{SA-285C at } 700^\circ\text{F}$$

Find: MAWP

Use: Morison section — PFT-18 and PFT-19; plain section — PFT-14, PFT-19, and PFT-51

Solve: Morison section, per PFT-18.1

$$P = Ct/D$$

where

$$C = 15,600 \text{ (see PFT-18.1)}$$

$$t = 0.625 \text{ in. (given)}$$

$$D = 36.5 \text{ in. (see PFT-18.1)}$$

$$P = \frac{(15,600)(0.625)}{36.5}$$

$$P = 267 \text{ psi}$$

Plain section, per PFT-19.2. The MAWP shall be calculated in accordance with PFT-14 and PFT-51.

Per PFT-51.1.2(a), determine if $D_o/t \geq 10$.

Calculate D_o/t

where

$$D_o = 37.5 \text{ in. (calculated)}$$

$$t = 0.75 \text{ (given)}$$

$$D_o/t = 37.5/0.75 = 50$$

Since D_o/t is greater than 10, follow the procedure outlined in PFT-51.1.2(a).

Step 1: Determine the ratios L/D_o and D_o/t .

Calculate L/D_o

where

$$L = 37 \text{ in. (see PFT-19.2)}$$

$$D_o = 37.5 \text{ in. (calculated)}$$

$$L/D_o = 37/37.5 = 0.99$$

Calculate D_o/t

where

$$D_o = 37.5 \text{ in. (calculated)}$$

$$t = 0.75 \text{ (given)}$$

$$D_o/t = 37.5/0.75 = 50$$

Step 2: Enter Fig. G of Section II, Part D, the value of $L/D_o = 0.99$

Step 3: Enter Fig. G of Section II, Part D, the value of $D_o/t = 50$

Find Factor A.

$$\text{Factor A} = 0.0039$$

Step 4: Enter Table A1 of Section II, Part D, for SA-285C at 700°F. The external pressure chart to be used is Fig. CS-2 of Section II, Part D. Enter Fig. CS-2 of Section II, Part D, and find the intersection of 0.0039 and 700°F.

Step 5: Find Factor B.

$$\text{Factor B} = 10,500$$

Step 6: Calculate MAWP

$$P = \frac{4(B)}{3(D_o/t)}$$

where

$$B = 10,500 \text{ (see Fig. CS-2 of Section II, Part D)}$$

$$D_o = 37.5 \text{ in. (calculated)}$$

$$t = 0.75 \text{ (given)}$$

$$P = \frac{4(10,500)}{3(37.5/0.75)}$$

$$P = 280 \text{ psi in plain section}$$

MAWP is 267 psi based on Morison section.

A-383 What wall thickness of firetube in an area absorbing heat would be required to carry 500 psi if the tube is seamless SA-192, 4 in. in diameter and 15 ft long?

Given:

$$D_o = 4 \text{ in.}$$

$$P = 500 \text{ psi}$$

$$L = 15 \text{ ft} = 180 \text{ in.}$$

Find: wall thickness of tube

Use: PFT-12, PFT-50, and PFT-51

Solve: Per PFT-51.1.2(a), determine if D_o/t is greater than 10.

Calculate $D_o/t \geq 10$

where

$$D_o = 4 \text{ in. (given)}$$

$$t = 0.125 \text{ in. (assumption)}$$

$$D_o/t = 4/0.125 = 32$$

Since D_o/t is greater than 10, follow the procedure outlined in PFT-51.1.2(a).

Step 1: Calculate L/D_o

where

$$L = 15 \text{ ft (given)}$$

$$D_o = 4 \text{ in. (given)}$$

$$L/D_o = 180/4$$

$$L/D_o = 45$$

Calculate D_o/t

where

$$D_o = 4 \text{ in. (given)}$$

$$t = 0.125 \text{ in. (assumption)}$$

$$D_o/t = 4/0.125 = 32$$

Step 2: Enter Fig. G of Section II, Part D, for $L/D_o = 45$

Step 3: Move horizontally to the line for $D_o/t = 32$. From this point of the intersection, move vertically downward to get Factor A.

$$\text{Factor A} = 0.0013$$

Step 4: Enter Table 1A of Section II, Part D, for $SA-192 \leq 700^\circ\text{F}$ per PFT-50 and PG-27.4, Note 2. Enter Fig. CS-1 of Section II, Part D, and find intersection of 0.0013 and 700°F .

Step 5: Move horizontally to the right to find Factor B.

$$\text{Factor B} = 7,000$$

Step 6: Calculate MAWP using the following formula:

$$P_a = \frac{4B}{3(D_o/t)}$$

where

$$B = 7,000 \text{ (see Fig. CS-1 of Section II, Part D)}$$

$$D_o = 4 \text{ in. (given)}$$

$$t = 0.125 \text{ in. (assumption)}$$

$$P_a = \frac{4(7,000)}{3(4/0.125)}$$

$$P_a = 292 \text{ psi}$$

Step 7: Since P_a is less than actual P , select a larger t and repeat the design procedure. Therefore, assume $t = 0.20$ in.

Per PFT-51.1.2(a), determine if D_o/t is greater than 10.

Calculate $D_o/t \geq 10$

where

$$D_o = 4 \text{ in. (given)}$$

$$t = 0.20 \text{ in. (assumption)}$$

$$D_o/t = 4/0.20 = 20$$

Since D_o/t is greater than 10, follow the procedure outlined in PFT-51.1.2(a).

Step 1: Calculate L/D_o

where

$$L = 15 \text{ ft (given)}$$

$$D_o = 4 \text{ in. (given)}$$

$$L/D_o = 180/4$$

$$L/D_o = 45$$

Calculate D_o/t

where

$$D_o = 4 \text{ in. (given)}$$

$$t = 0.20 \text{ in. (assumption)}$$

$$D_o/t = 4/0.20$$

$$D_o/t = 20$$

Step 2: Enter Fig. G for $L/D_o = 45$

Step 3: Move horizontally to the line for $D_o/t = 20$.

$$\text{Factor A} = 0.0028$$

Step 4: Enter Table 1A of Section II, Part D, for $SA-192 \leq 700^\circ\text{F}$ per PFT-50 and PG-27.4, Note 2. Enter Fig. CS-1 of Section II, Part D, and find the intersection of 0.0028 and 700°F .

Step 5: Move horizontally to the right to find Factor B.

$$\text{Factor B} = 8,000$$

Step 6: Calculate MAWP using the following formula:

$$P = \frac{4B}{3 (D_o/t)}$$

where

$B = 8,000$ (see Fig. CS-1 of Section II, Part D)

$D_o = 4$ in. (given)

$t = 0.20$ in. (assumption)

$$P_a = \frac{4(8,000)}{3(4/0.20)}$$

$$P_a = 533 \text{ psi}$$

Step 7: since P_a is greater than P , the required thickness equals 0.25 in.

$$t = 0.25 \text{ in.}$$

CODES, STANDARDS, AND SPECIFICATIONS REFERENCED IN TEXT

A-360 REFERENCED STANDARDS

Specific editions of standards referenced in this Section are shown in Table A-360. It is not practical to refer to a specific edition of each standard throughout the text, so edition references are centralized here. Table A-360 will be revised at intervals and reissued as needed.

TABLE A-360
CODES, STANDARDS, AND SPECIFICATIONS REFERENCED IN TEXT

ASME Standards

B1.20.1-1983(R1992)	Pipe Threads, General Purpose (Inch)
B16.1-1989	Cast Iron Pipe Flanges and Flanged Fittings
B16.3-1992	Malleable Iron Threaded Fittings, Classes 150 and 300
B16.4-1992	Gray Iron Threaded Fittings, Class 125 and 250
B16.5-1996	Pipe Flanges and Flanged Fittings [Note (1)]
B16.9-1993	Factory-Made Wrought Steel Buttwelding Fittings
B16.11-1996	Forged Fittings, Socket-Welding and Threaded
B16.15-1985(R1994)	Cast Bronze Threaded Fittings, Class 125 and 250
B16.20-1993	Ring-Joint Gaskets and Grooves for Steel Pipe Flanges
B16.24-1991(R1995)	Cast Copper Alloy Pipe Flanges and Flanged Fittings
B16.25-1997	Buttwelding Ends
B16.28-1994	Wrought Steel Buttwelding Short Radius Elbows and Returns
B16.34-1996	Valves — Flanged, Threaded, and Welding End [Note (1)]
B16.42-1987(R1997)	Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300
B31.1-1998 & 2000 Addenda	Power Piping [Notes (2), (3), (4), (5), and (6)]
B36.10M-1996	Welded and Seamless Wrought Steel Pipe
QAI-1	Qualifications for Authorized Inspection

ASTM

A 126-1995	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
B 139-1995	Standard Specification for Phosphor-Bronze Rod, Bar, and Shapes
E 8-1998	Standard Test Methods of Tension Testing of Metallic Materials
E 125-63(R1997)	Reference Photographs for Magnetic Particle Indications on Ferrous Castings
E 186-98	Standard Reference Radiographs for Heavy-Walled [2 to 4½ in. (51 to 114 mm)] Steel Castings
E 280-98	Standard Reference Radiographs for Heavy-Walled [4½ to 12 in. (114 to 305 mm)] Steel Castings
E 446-98	Standard Reference Radiographs for Steel Casings up to 2 in. (51 mm) in Thickness

ASME Performance Test Code

PTC 25-1994	Pressure Relief Devices
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ASNT Specification

SNT-TC-1A-1996 with the 1998 Addenda	Recommended Practice for Nondestructive Testing Personnel Qualification and Certification
ACCP, Revision 3, November 1997	Central Certification Program

GENERAL NOTE: The issue date shown immediately following the hyphen after the number of the standard (e.g., B1.20.1-1983) is the effective date of issue (edition) of the standard.

NOTES:

- (1) Saturated steam ratings and boiler feed and blowoff ratings for B16.5 flanges and B16.34 Standard Class valves of Material Group 1.1 are given in Table A-361. For other conditions, other materials, Special Class or Limited Class valves, or intermediate rating valves, see ASME B16.5 and ASME B16.34 for pressure-temperature limitations.
- (2) Note 1 of Table A-1 of B31.1, Appendix A, applies to Electric Resistance Welded A-333, Grade 6 material.
- (3) The weld end transition of Fig. PG-42.1 is also acceptable.
- (4) The use of diverter valves under Section I reheater safety valves is prohibited.
- (5) The minimum carbon content specified in paras. 124.2(d) and 127.2.1 and in Note (18) of Table A-2 of B31.1 shall only apply to low alloy steels whose nominal composition is 2¼ Cr-1 Mo.
- (6) Paragraph 136.4.5 (A-5) is not applicable to Boiler External Piping.

TABLE A-361
MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP) FOR THE USE OF ASME
B16.5 PIPE FLANGES AND FLANGED FITTINGS AND ASME/ANSI B16.34 VALVES —
FLANGED, THREADED, AND WELDING END (STANDARD CLASS)

ASME B16.5 and B16.34 Class	Maximum Allowable Working Pressure (MAWP), Except as Noted	
	Steam Service at Saturation Temperature, psi (ksi) [Notes (1), (4)]	Boiler Feed and Blowoff Line Service, psi (ksi) [Notes (1), (2), (4)]
150	205 (1 400)	170 (1 200)
300	605 (4 200)	490 (3 300)
400	785 (5 400)	640 (4 400)
600	1,135 (7 800)	935 (6 400)
900	1,635 (11 200)	1,430 (9 800)
1500	2,675 (18 400)	2,455 (16 900)
2500	3,206 (22 100) [Note (3)]	3,206 (22 100) [Note (3)]

NOTES:

- (1) Adjusted pressure ratings for Steel Pipe Flanges and Flanged Fittings, for steam service at saturation temperature corresponding to the pressure, derived from Tables 1A and 2, using material group 1.1 of ASME B16.5. Adjusted pressure ratings for Steel Valves (Standard Class) for steam service at saturation temperature corresponding to the pressure, derived from Tables 1 and 2-1.1A, using material group 1.1 of ASME B16.34. For other materials or design temperatures exceeding saturation temperature, see ASME B16.5 and ASME B16.34 for pressure-temperature limitations. The pressure listed is rounded to the nearest 5 psi.
- (2) Pressures shown include the factor for boiler feed and blowoff line service, corrected for line design temperature, as required by ASME B31.1. The pressure listed is rounded to the nearest 5 psi.
- (3) Rating exceeds critical pressure of water.
- (4) The pressure-temperature ratings provided herein apply to the flange and do not necessarily reflect the rating of the assembled flange joint. The pressure-temperature ratings provided apply to the gasketed and bolted flange joint only when the gasket and studs conform to the recommendations of ASME B16.5.

SI UNITS

The 2001 Edition of the Boiler and Pressure Vessel Code is based on U.S. Customary (ft-lb) units of measurement, which are to be regarded as the standard. This supplement is provided as a convenience to the Code user and contains SI conversion factors for units contained in the Code. **01**

LIST OF SI UNITS FOR USE WITH ASME BOILER AND PRESSURE VESSEL CODE¹

Quantity	Unit	Symbol	Other Units or Limitations
Space and Time			
plane angle	radian	rad	degree (decimalized)
length	meter	m	
area	square meter	m ²	
volume	cubic meter	m ³	liter (L) for liquid only (use without prefix other than in milliliter, mL)
time	second	s	minute (min), hour (h), day (d), week, and year
Periodic and Related Phenomena			
frequency	hertz	Hz	revolutions per second (r/s)
rotational frequency	revolutions per second	s ⁻¹	revolutions per minute (r/m)
Mechanics			
mass	kilogram	kg	
density	kilogram per cubic meter	kg/m ³	
moment of inertia	kilogram · meter ²	kg · m ²	
force	newton	N	
moment of force (torque)	newton-meter	N · m	
pressure and stress	pascal	Pa	(pascal = newton per square meter)
energy, work	joule	J	kilowatt-hour (kW · h)
power	watt	W	
impact strength	joule	J	
section modulus	meter ³	m ³	
moment of section (second moment of area)	meter ⁴	m ⁴	
fracture toughness	Pa · $\sqrt{m}$		
Heat			
temperature — thermodynamic [Note (2)]	kelvin	K	degree Celsius (°C)
temperature — other than thermodynamic	degree Celsius	°C	kelvin (K)
linear expansion coefficient	meter per meter-kelvin	K ⁻¹	°C ⁻¹
quantity of heat	joule	J	
heat flow rate	watt	W	
thermal conductivity	watt per meter-kelvin	W/(m · K)	W/(m · °C)
thermal diffusivity	square meter per second	m ² /s	
specific heat capacity	joule per kilogram-kelvin	J/(kg · K)	J/(kg · °C)
Electricity and Magnetism			
electric current	ampere	A	
electric potential	volt	V	
current density	ampere per meter ²	A/m ²	
magnetic field strength	ampere per meter	A/m	

NOTES:

- (1) Conversion factors between SI units and U.S. customary are given in SI-1, "ASME Orientation and Guide for Use of SI (Metric) Units," and ASTM E 380.
- (2) Preferred use for temperature and temperature interval is degrees Celsius (°C), except for thermodynamic and cryogenic work where kelvins may be more suitable. For temperature interval, 1 K = 1°C exactly.

COMMONLY USED CONVERSION FACTORS¹
(For Others See ASTM E 380)

Quantity	To Convert From	To	Multiply by [Note (2)]	
plane angle	degree	rad	1.745 329	E-02
length	in	m	2.54*	E-02
	ft	m	3.048*	E-01
	yd	m	9.144*	E-01
area	in ²	m ²	6.451 6*	E-04
	ft ²	m ²	9.290 304*	E-02
	yd ²	m ²	8.361 274	E-01
volume	in ³	m ³	1.638 706	E-05
	ft ³	m ³	2.831 685	E-02
	US gallon	m ³	3.785 412	E-03
	Imperial gallon	m ³	4.546 09	E-03
	liter	m ³	1.0*	E-03
mass	lbm	kg	4.535 924	E-01
	ton (metric) (mass)	kg	1.000 00*	E+03
	ton (short 2,000 lbm)	kg	9.071 847	E+02
force	kgf	N	9.806 65*	E+00
	lbf	N	4.448 222	E+00
bending, torque	kgf · m	N · m	9.806 65*	E+00
	lbf · in	N · m	1.129 848	E-01
	lbf · ft	N · m	1.355 818	E+00
pressure, stress	kgf/m ²	Pa	9.806 65*	E+00
	lbf/ft ²	Pa	4.788 026	E+01
	lbf/in ² (psi)	Pa	6.894 757	E+03
	kips/in ²	Pa	6.894 757	E+06
	bar	Pa	1.0*	E+05
energy, work	Btu (IT) [Note (3)]	J	1.055 056	E+03
	ft · lbf	J	1.355 818	E+00
power	hp (550 ft · lbf/s)	W	7.456 999	E+02
fracture toughness	ksi $\sqrt{\text{in}}$	Pa · $\sqrt{\text{m}}$	1.098 843	E+06
temperature	°C	K	$t_K = t_C + 273.15$	
	°F	K	$t_K = (t_F + 459.67)/1.8$	
	°F	°C	$t_C = (t_F - 32)/1.8$	
temperature interval	°C	K	1.0*	E+00
	°F	K or °C	5.555 555	E-01

NOTES:

- (1) Care should be taken when converting formulas or equations that contain constant terms or factors. The value of these terms must be understood and may also require conversion.
- (2)(a) Relationships that are exact in terms of the base units are followed by a single asterisk.
- (b) The factors are written as a number greater than 1 and less than 10 with 6 or less decimal places. The number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example: 3.523 907 E-02 is $3.523\ 907 \times 10^{-2}$ or 0.035 239 07.
- (3) International Table

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ASME Boiler and Pressure Vessel Code

SECTION I

INTERPRETATIONS

Volume 48

The Interpretations to the Code will be issued twice a year (July and December) up to the publication of the 2004 Edition of the Code. The Interpretations for each individual Section are published separately and are part of the update service to that Section; Interpretations of Section III, Divisions 1 and 2, are part of the update service to Section III, Subsection NCA.

Interpretations Volumes 42 through 47 were included with the update service to the 1998 Edition of the Code; Volume 48 is the first Interpretations volume to be included with the update service to the 2001 Edition.

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